POWER PLANT ENGINEERING

Established Over 31 Years

VOL. XXXI CHICAGO, SEPTEMBER 1, 1927 No. 17

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Published on the 1st and 15th of each Month by the
Technical Publishing Co., 53 West Jackson Blvd., Chicago
New York Office, 150 Nassau Street

Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1926, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations
Circulation of this Issue 22,800

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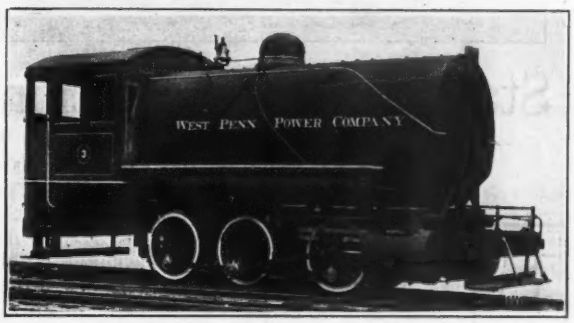


Springdale Operates a Fireless Cooker

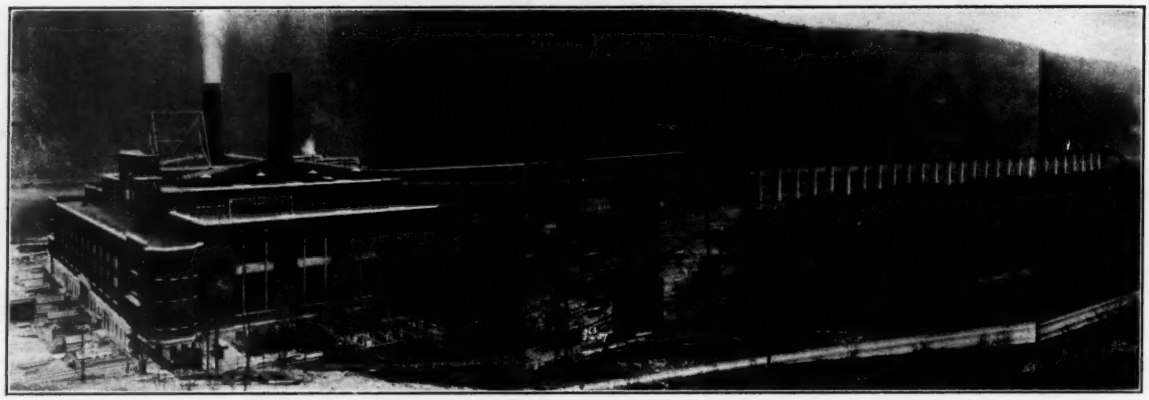
"NOW, I WANT TO SHOW YOU our fireless cooker," said the chief engineer, after taking the editor on an interesting inspection trip through the great power plant of the West Penn Power Co. at Springdale.

At these words, the editorial mouth began to water. "Aha!" thought the editor, "this plant must have its own cafeteria." The editor had not eaten luncheon and had consumed considerable energy in inspecting many fascinating engineering details. Hence the aforementioned editorial watering at the mouth, accompanied by visions of a large, juicy roast beef sandwich or something equally sustaining out of the fireless cooker.

"There," said the chief, "what do you think of that?" He pointed to the locomotive illustrated above. "That's what we call our fireless cooker!"

It was nothing more nor less than a fireless switching locomotive used for shifting railroad cars in the plant yard and for hauling 30-t. side dump ash cars out of the plant. There is no firebox, fire tubes or stack. A water storage tank, of 670 cu. ft. capacity and well insulated, contains water into which steam is charged direct from the main power house boilers at 350 lb. pressure, the tank being charged to about 310 lb. It is, in short, a portable steam accumulator. Live steam is drawn from this tank to operate the standard engine equipment driving the locomotive, consisting of two 24 by 24-in. steam cylinders, driving six 46-in. driving wheels. Baffles in the tank prevent movement of the water on an uneven track. To prevent mechanical strains in the tank, it has been found important not to draw the tank pressure below 150 lb. The locomotive has proved low in maintenance cost, can be handled by one man and operates several hours on one charge of high-pressure steam. It has proved extremely reliable.

Nevertheless, the editor will not soon forget how his trusting nature was betrayed by the chief's casual reference to the fireless cooker.



Stanton Power Station Burns Anthracite Culm

NEW BASE LOAD CENTRAL STATION AT WEST PITTSTON, PA., IS DIVIDED IN TWO SECTIONS, EACH HAVING AN INITIAL 45,000-KW. TURBINE WITH REHEAT, FLOATING HEAD CONDENSERS, HOUSE GENERATOR AND UNUSUAL ARRANGEMENT OF CIRCULATING PUMPS

STANTON POWER STATION, located at West Pittston, Pa. on the Susquehanna River, has recently placed in operation its initial installation of 90,000 kw. in two units in a plant designed to burn anthracite culm from the various neighboring coal districts and to supply base load power on two separate transmission lines. The plant is designed for an ultimate capacity of 8 units of the same size as the present two. Of special interest is the layout of the plant in two sections divided longitudinally by the boiler room firing aisle, each section containing a 45,000-kw. turbo-generator unit served by three stoker-fired standard boilers and one reheat boiler. The ultimate layout is to contain four 45,000-hp. units on each side. The two-section arrangement was adopted because the plant is a joint project of the American Gas & Electric Co. and the Pennsylvania Power & Light Co. and the transmission lines of the two companies are supplied by the separate sections, although they can be tied together electrically, if necessary, as can also the steam, water and other systems.

No high voltage switching is performed inside the plant; each generator is connected directly to a bank of step-up transformers just outside the turbine room wall and switching is done in the outdoor switchyard on the high tension side of the transformers. One section of the plant feeds into a 66,000-v. transmission line of the Scranton Electric Co. and the other into a 66,000-v. line of the Pennsylvania Power and Light Co. A tie line running over the roof of the plant on a

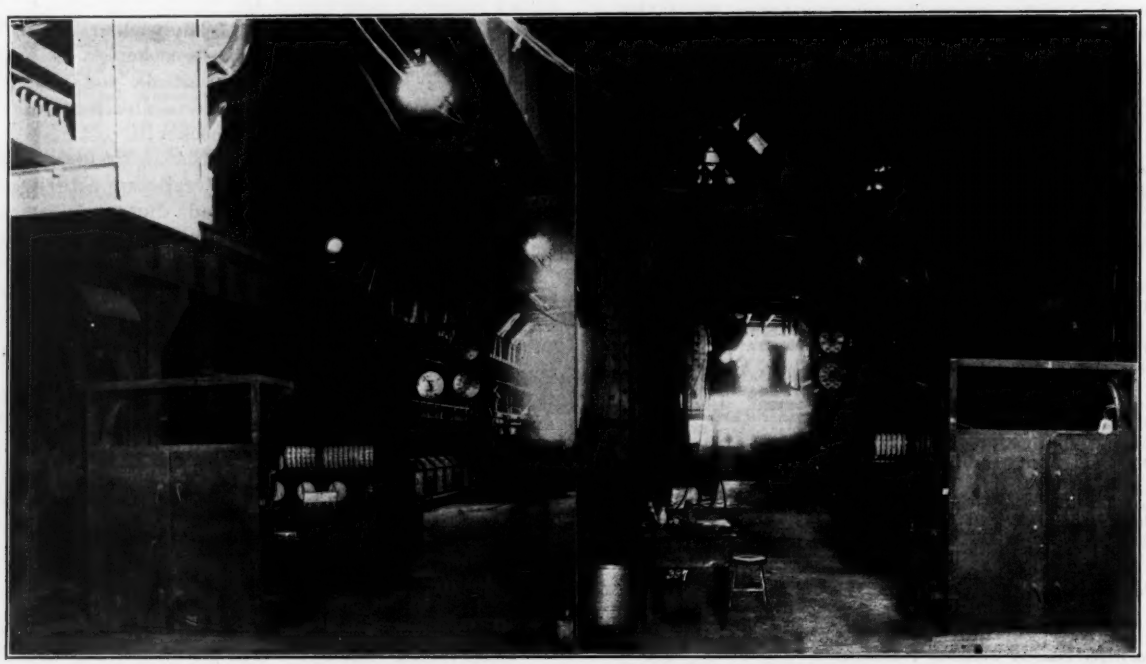


FIG. 1. CRANES FOR GENERAL SERVICE ARE A FEATURE OF THE STANTON BOILER ROOM. CHAIN GRATE STOKERS BURN ANTHRACITE CULM UNDER 8 BOILERS, FOUR FOR EACH TURBINE

steel structure connects these two transmission lines when necessary.

This plant is designed for 625 lb. pressure, using single cylinder turbines designed for reheat, with extraction feed water heating, floating head condensers and a house generator on the main shaft. An unusual arrangement of circulating pumps is used. Furnaces are of special design to burn anthracite culm; preheated air for the stokers is tempered by water economizers and air is used for soot blowing. The plant is built on a concrete mat extending under the whole of the building about 28 ft. below high water.

Stanton Will Use Anthracite Culm as Fuel

Anthracite culm will be the principal fuel used at Stanton, since the mines of that district have large supplies of this fuel available at a comparatively low price. It has a heat value of approximately 9000-10,500 B.t.u. per pound as fired. It has a relatively high ash content and a moisture content averaging 12 to 14 per cent. It has been found, after many experiments by the company, that this culm can be burned successfully on chain grate stokers with proper air supply.

Coal will be handled by equipment similar to that used at the Twin Branch* and Philo† stations, the headpiece showing the storage space, of about 300,000 t. capacity and the conveyors to the boiler house. At Stanton, however, the fuel does not need to be crushed, since it is already in such a condition that about 50 per cent of it will pass through a $\frac{3}{16}$-in. mesh screen.

Cars of coal, after being weighed, are dumped at the end of the storage space farthest from the plant by a rotary car dumper directly into a hopper feeding the inclined conveyor belt. This conveys the coal to two belt conveyors on the long trestle, on which is also mounted a coal storage crane. This crane, equipped with a shuttle conveyor, can take the coal from the

*Power Plant Engineering, Jan. 15, 1926.
†Ibid, June 1, 1925.

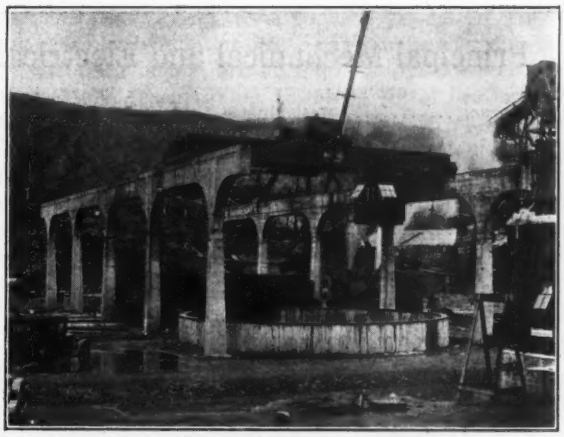


FIG. 3. ASH IS SLUICED TO CONCRETE TANKS OUTSIDE THE PLANT, AND LOADED INTO CARS FOR DISPOSAL

belts and distribute it over the storage space on either side of the trestle or the coal can be allowed to pass directly to the transfer house, where it is transferred to the two belt conveyors serving the coal bunkers of each boiler battery. These two belt conveyors, shown in the headpiece and in Fig. 2, are designed to serve the ultimate plant. Further extension of the plant will be to the south along the line of these conveyors, enclosing them.

The transfer house is used primarily to change the direction of the belt conveyors; the lower part of this house forms a convenient location for the coal handling substation. Here are located motor generator sets and controls for the motors driving the various parts of the coal-handling system.

Automatic electric scales are placed on each of the conveyor belts feeding the bunkers, also at each boiler, thus giving complete checks on fuel.

Furnaces are of the construction shown in Fig. 2, with a long arch at the rear to assist in burning out the

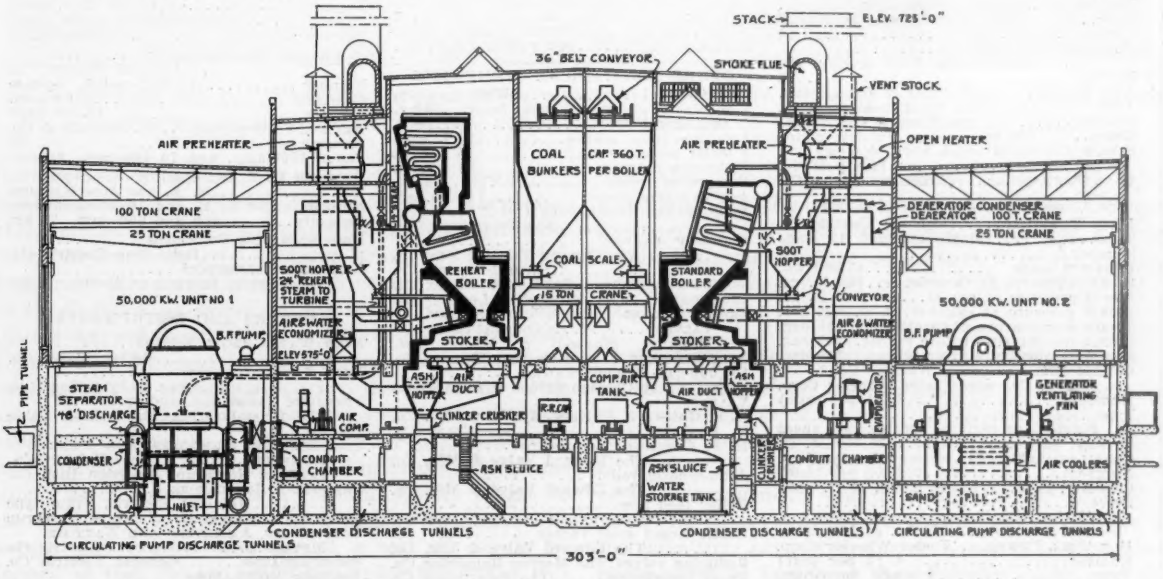


FIG. 2. CROSS-SECTION SHOWING PLANT DIVIDED IN CENTER, ARRANGEMENT OF FURNACES AND SOOT HOPPERS AND LOCATION OF AIR PREHEATERS AND AIR-WATER ECONOMIZERS

Principal Mechanical and Electrical Equipment in Stanton Power Station

GENERAL

LOCATION.....West Pittston, Pa.
CAPACITY
Present ..... 90,000 kw.
Ultimate ..... 360,000 kw.
VOLUME OF PRESENT BUILDING
Total, cu. ft. per kw.....83.9
Available for future.....18.3

Net total 65.6
Built for .....
American Gas & Electric Co. and Pennsylvania Power & Light Co.
CONSULTING ENGINEERS .....
.....Sargent & Lundy, Inc.
BUILDING CONTRACTOR..The Foundation Co.

COMBUSTION EQUIPMENT

STANDARD BOILERS...Babcock & Wilcox Co.
Number 6
Heating Surface, each.....17,962 sq. ft.
Superheating surface..... 2,800 sq. ft.
Steam pressure .....625 lb.
Steam temperature .....750 deg. F.
Steam capacity, each....175,000 lb. per hr.
REHEAT BOILERS....Babcock & Wilcox Co.
Number 2
Water heating surface.....5978 sq. ft.
Superheating surface.....1600 sq. ft.
Reheating surface .....13,481 sq. ft.
Steam capacity, per hr.....83,000 lb.
Reheating capacity, per hr.....349,000 lb.
FURNACES
Combustion arches.....M. H. Detrick Co.
Masonry settings..Nat'l Power Const. Co.
ECONOMIZERS.....Babcock & Wilcox Co.
Type.....Air and water
Number 8
Heating surface, each.....3011 sq. ft.
AIR PREHEATERS..The Air Preheater Corp.
Type ..... Ljungstrom
Number.....16 (2 per boiler)
Heating surface, each.....40,500 sq. ft.
Fans.....1 f.d. and 1 i.d. in each unit
F.D. fan capacity.....33,000 c.f.m.
Drive.....175 hp. motor
STOKERS.....Babcock & Wilcox Co.
Type .....Chain grate
Number 8
Drive.....15 hp. G.E., d.c. motor
STEEL STACKS.....American Bridge Co.
Number 2
Diameter inside .....16 ft.
Height above b.r.fl.....150 ft.
BOILER BREECHINGS AND AIR DUCTS..
.....Connery & Co., Inc.

COAL AND ASH HANDLING

CAR DUMPER..Wellman-Seaver-Morgan Co.
Capacity.....100 t. car in 2 min.
COAL CONVEYORS .....
6—36-in. belts A. G. & E. Co. design
DISTRIBUTING CRANE .....
.....A. G. & E. Co. design
COAL SPOUT SWINGERS....Henry Pratt Co.
AUTOMATIC SCALES ON CONVEYORS....
.....Merrick Scale Co.
BOILER COAL SCALES..Richardson Scale Co.
Type.....Apron feed, automatic
Number 16
CLINKER GRINDERS .....
.....Westinghouse Elec. & Mfg. Co.
Number 8
ASH SLUICE.....Sargent & Lundy, Inc.
ASH PUMP..American Manganese Steel Co.
Number.....2, single-stage centrifugal
Drive.....200-hp. Western Electric motor
SCREW CONVEYOR FROM SOOT HOPPERS
.....Link-Belt Co.
COAL BUNKERS.....American Bridge Co.

TURBINES AND AUXILIARIES

MAIN TURBINES.....General Electric Co.
Type.....Single cylinder, 19 stage
Number 2
Capacity, each .....45,000 kw.
Steam pressure at throttle.....600 lb. ga.
Steam pressure at reheat.....160 lb. ga.
Steam pressure at exhaust..1 in. Hg. abs.
Steam temperature at throttle....725 deg.
Steam temperature before reheat..505 deg.
Steam temperature after reheat...725 deg.
CONDENSERS .....Wheeler Cond.
& Eng. Co., now Foster Wheeler Corp.
Number.....2 (1 per unit)
Type .....
Single pass, surface, floating tube sheet
Surface, each.....35,000 sq. ft.
CIRCULATING PUMPS .Foster Wheeler Corp.
Number.....2 (1 per unit)
Capacity, each....72,000 g.p.m. 15 ft. head
Drive .....
450-hp. Allis-Chalmers motor, 275 r.p.m.
.....240 hp. at 200 r.p.m.
HOT WELL PUMPS....Foster Wheeler Corp.
Number.....4 (2 per unit)
Type.....2 stage centrifugal
Capacity .....900 g.p.m.
Drive.....100-hp. Allis-Chalmers motor
AIR PUMPS.....Foster Wheeler Corp.
Number.....2 (1 per unit)
Type.....3-element 2-stage steam jet
TRAVELLING SCREENS.....Chain Belt Co.
Number 5
Size, each.....50 ft. 3 in. by 7 ft.
Drive..10-hp., 2-speed squirrel cage motor

EVAPORATOR AND HEATERS

EVAPORATOR.....Foster Wheeler Corp.
Number.....1, Quadruple effect
Capacity.....40,000 lb. an hr.
OPEN FEED WATER HEATER.....Elliott Co.
Number 2
Capacity.....355,000 lb. per hr.
EXTRACTION HEATERS .....
.....Foster Wheeler Corp.
Number 2
Type .....Low pressure
Surface, each.....1800 sq. ft.
GLAND STEAM CONDENSERS.....
.....Foster Wheeler Corp.
Number 2
DEAERATOR..... Elliott Co.
Number 2
Capacity.....350,000 lb. per hr.

BOILER FEED AND OTHER PUMPS

BOILER FEED PUMPS.....
.....Bethlehem Shipbuilding Corp.
Number.....2 centrifugal, 1-stage
Capacity, each....800 g.p.m., 1848 ft. head
Drive.....Bethlehem Weir turbine
BOILER FEED PUMPS.....
.....A. S. Cameron Steam Pump Co.
Number.....2 centrifugal, 6-stage
Capacity.....800 g.p.m., 1848 ft. head
Drive.....600-hp. G. E. slipring motor
BILGE PUMPS.....Yeomans Bros. Co.
Number .....5 sets
Capacity, each.....500 g.p.m.
SERVICE PUMPS....Allis-Chalmers Mfg. Co.
Number.....3 single stage centrifugal
Capacity, each....1500 g.p.m., 237 ft. hd.
HEATER CONDENSATE PUMPS.....
.....Allis-Chalmers Mfg. Co.
Number 2
Type.....Single stage centrifugal
Capacity, each.....100 g.p.m., 160 ft. hd.
ICE MELTING PUMP..Foster Wheeler Corp.
Number 1
Type .....Bi-rotor centrifugal
Capacity....72,000 g.p.m. against 15 ft. hd.
Drive.....450-hp., 275-r.p.m. motor
MAKEUP PUMPS...Allis-Chalmers Mfg. Co.
Number 3
Capacity, each.....200 g.p.m., 190 ft. hd.
DEEP WELL PUMPS..American Well Works
Number 3
Type.....Vertical Multi-stage
Capacity, each....1000 g.p.m., 210 ft. hd.
PRIMARY MAKEUP PUMPS.....
.....Yeomans Bros. Co.
Number 4
Type .....Horizontal centrifugal
Capacity, each.....20 g.p.m., 123 ft. hd.
HOT WATER CIRCULATING PUMPS.....
.....Allis-Chalmers Mfg. Co.
Number 2
Type .....Horizontal-single stage
Capacity, each.....500 g.p.m., 50 ft. hd.

OTHER MECHANICAL EQUIPMENT

CRANES .....Whiting Corp.
2 turbine room cranes, main hoist...100 t.
Auxiliary hoist .....10 t.
2 turbine room cranes.....25 t. each
2 boiler room cranes.....15 t. each
Cribhouse crane.....25 t. each
Pumproom crane .....15 t.
Ash handling crane.....1½ cu. yd.
FEED WATER REGULATORS ("S-C").....
.....The Swartwout Co.
BLOWOFF VALVES .....
.....The Edward Valve & Mfg. Co.
.....Yarnall-Waring Co.
WATER COLUMNS....Babcock & Wilcox Co.
Illuminators.....Sargent & Lundy, Inc.
SAFETY VALVES & REH'T BOIL. RELIEF VALVES .....(Consolidated)
Manning, Maxwell & Moore, Inc.
SOOT BLOWERS....Vulcan Soot Cleaner Co.
100,000-GAL. WATER TANKS.....
....2 by Chicago Bridge & Iron Works
VALVES
L. P. Gates.....Kennedy Valve Mfg. Co.
H. P. Gates.....Crane Co.
H. P. Checks or non-return.....
.....The Edward Valve & Mfg. Co.
Atmospheric relief .....
.....The Edward Valve & Mfg. Co.
Boiler feed line.....
The Edward Valve & Mfg. Co., Crane Co.
Small forged steel valves.....
.....The Edward Valve & Mfg. Co.
Reducing valves.The Mercon Regulator Co.
PUMP GOVERNORS.....The Swartwout Co.
TURBINE BLEEDER LINE REGULATORS..
.....The Mercon Regulator Co.
MOTOR OPERATORS FOR VALVES.....
.....Dean (Cutler-Hammer Mfg. Co.)
H. P. PIPING.....Crane Co.
PIPING INSTALLATION .....
.....Pittsburgh Piping & Equip. Co.
PIPE AND DUCT INSULATION.....
.....Ehret Magnesia Mfg. Co.
TRAPS.....The Fisher Governor Co., Inc.
HEATING SYSTEM .....
Sargent & Lundy, Inc. design installed by Gaylord & Butler.
OIL PURIFIERS....De Laval Separator Co.
Number 4
Capacity, each .....300 g.p.h.
OIL FILTERS.....S. F. Bowser & Co., Inc.
Number 4
Capacity, each .....300 g.p.h.
OIL COOLERS.....Andale Engineering Co.
Type .....Surface, tubular
Number 4
ELEVATORS.....Otis Elevator Co.
STEAM SEPARATORS....M. W. Kellogg Co.
Number 2
Type..Welded steel on turbine steam leads
AIR COMPRESSOR...Sullivan Machinery Co.
Number.....2, each 1131 c.f.m.
Drive.....G.E. 285-hp. motor
CONDENSER EXPANSION JOINTS.....
.....Henry Pratt Co.
EXPANSION JOINTS (other).....Crane Co.
FLOORING AND STAIRS
Mitco grating.....Hendrick Mfg. Co.
Installed by Dauchy Iron Works
DAMPER CONTROL.....D. H. Skeen & Co.

PRINCIPAL ELECTRICAL EQUIPMENT

MAIN GENERATORS....General Electric Co.
Number 2
Capacity, each.....45,000 kw. 0.85 p.f.
Voltage.....11,000-v., 3-phase, 60 cycle
Speed .....1800 r.p.m.
HOUSE GENERATORS..General Electric Co.
Number 2
Drive.....On main shaft
Capacity.....2300 kw., 0.7 p.f., 2300 v.
MAIN GENERATOR EXCITERS.....G. E. Co.
Number.....2 direct connected
Capacity.....250 kw., 250 v.
HOUSE GENERATOR EXCITERS.....G. E. Co.
Number.....2 direct connected
Capacity.....35 kw., 250-v.
STORAGE BATTERIES .....
.....Electric Storage Battery Co.
1 120-cell, 70-amp. 8-hr. power battery
1 120-cell, 40-amp. 8-hr. control battery
MOTOR GENERATOR SETS
3 10-kw. for bat. charging, General Electric.
2 100-kw. for stoker motors, Allis-Chalmers Mfg. Co.
GENERATOR AIR COOLERS....Gen. Elec. Co.
FANS FOR AIR COOLING SYSTEM.....
.....The Green Fuel Economizer Co.
MAIN TRANSFORMERS .....
.....Westinghouse Elec. & Mfg. Co.
Number 7
Capacity.....17,500 kv.a. each
Type.....Water-cooled, single phase
Voltage 11,000/69,300
AUXILIARY TRANSFORMERS .....
.....General Electric Co.
Number .....1—Self-cooled, 3-phase
Capacity .....3500 kv.a.
Voltage 69,300/2300
REYROLLE SWITCHES.....A. Reyrolle & Co.
Number 79
Cap.9 1500-amp. and 70 400-amp., 6600-v.
OUTDOOR H. T. OIL CIRCUIT BREAKERS
.....G. E. and Westinghouse
Number....10 G. E. and 10 Westinghouse
Capacity.....400 and 600 amp., 73 kv.
DISCONNECTING SWITCHES .....
.....Delta-Star Electric Co.
LIGHTNING ARRESTERS .....
..3 General Electric oxide-film, 73-kv.

METERS AND INSTRUMENTS

FEED WATER FLOW METERS.....
.....Bailey Meter Co.
LOAD INDICATORS, etc.....
.....Chas. Cory & Son, Inc.
PRESSURE GAGES, ind. and rec.....
The Bristol Co. & The Ashton Valve Co.
TEMPERATURE RECORDERS AND THERMOMETERS.....The Bristol Co., Leeds & Northrup, Precision Inst. Co.
FREQUENCY INDICATORS .....
.....General Electric, Fram type
FREQUENCY METERS.....Leeds & Northrup
VOLTMETERS, AMMETERS AND WATT-HR. METERS.....General Electric Co.
SWITCHBOARDS.....General Electric Co.
VOLTAGE REGULATORS
Main generator.Am. Brown Bov. Elec. Corp.
House generator.....General Electric Co.

fuel thoroughly. The furnaces are divided into two combustion chambers by narrow throats. Preheated air is introduced into these throats to produce complete combustion of the unburned gases and small particles of fuel in the upper part of the furnace. This action is similar to that of a bunsen burner. The preheated air for these throats is drawn from the main duct just above the economizers as shown in Fig. 2. In passing through the air ports of the furnace throat, the air also helps to cool this throat. No water-cooled or air-cooled walls are used in the furnace.

Flue gas, after passing through the boiler, goes of the station, Fig. 3, from which a 1½-cu. yd. traveling crane loads it into railroad cars for further disposal.

Standard boilers are of the cross-drum water tube type, Fig. 2, each having 17,962 sq. ft. of heating surface in 3 tube decks with a 2800-sq. ft. superheater between the first and second decks. Both standard and reheat boilers have only two passes. Each standard boiler is designed to produce a maximum of 175,000 lb. of steam an hour at 625 lb. pressure and 750 deg. total temperature. Each reheat boiler consists of a single deck of boiler tubes with a 1600-sq. ft. primary superheater above it and interstage superheater above this.

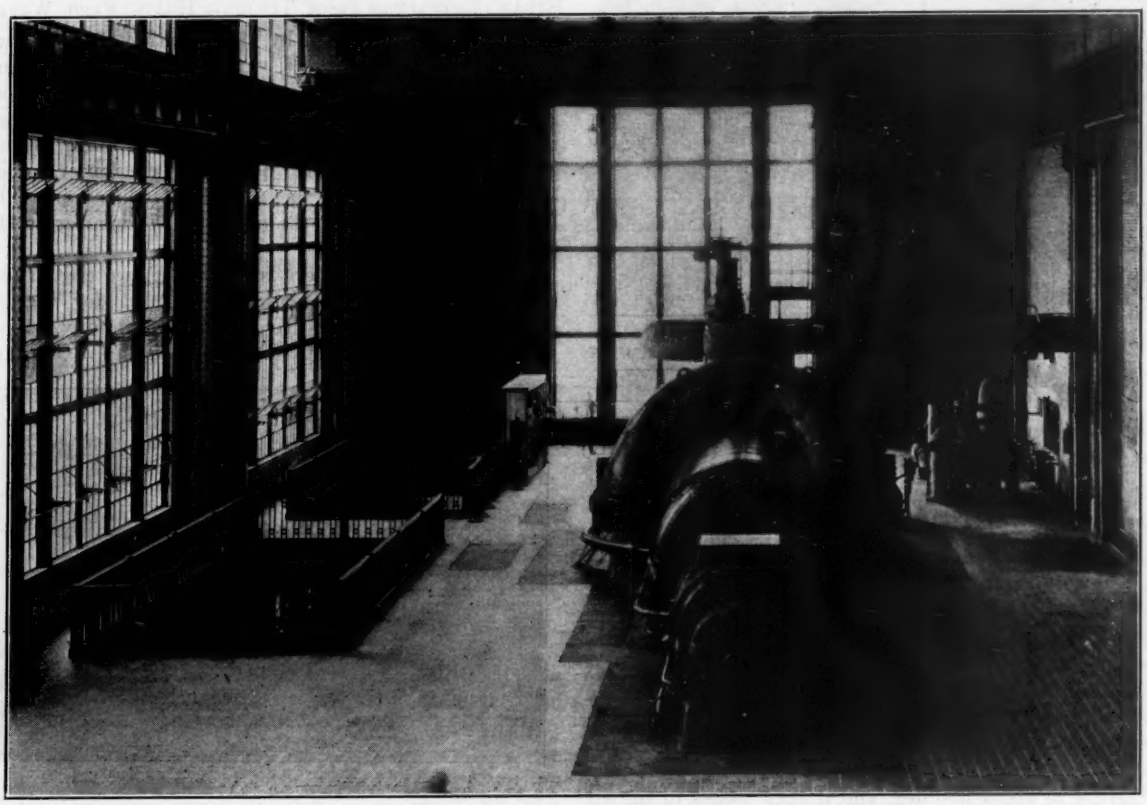


FIG. 4. ON EACH SIDE IS A TURBINE ROOM CONTAINING THE INITIAL 45,000-KW. TURBINE UNIT, WITH HOUSE GENERATOR AND EXCITERS ON MAIN SHAFT; BOILER FEED PUMPS ARE IN RIGHT HAND CORNER OF ROOM

through a soot hopper just behind it. On account of the low grade and fineness of the fuel used, a considerable amount of unburned particles is deposited here. This unburned material is taken from bottom of the hopper by screw conveyors which return it to the rear of the furnace, as shown in Fig. 2. If it is not completely burned here, it is again caught at the soot hopper and returned to the furnace, the process continuing until it is consumed, when the ash drops to the ash hopper. These ash hoppers are of about 38 t. capacity and feed to a clinker crusher just below, the ash then falling to a sluiceway. This crusher functions chiefly as a feeder to give a constant supply of ash to the sluiceway, rather than as a clinker crusher. The hopper and crusher also permit a seal of ash to be formed so that the air conditions under the stoker will not be disturbed. The sluice carries the ash out of the plant to two cylindrical concrete pits on the north side

The reheat boiler, is designed to take 349,000 lb. of steam an hour from the turbine, raise its temperature from about 480 deg. at 160 lb. gage to 725 deg. at practically the same pressure and return it to the turbine. At the same time, it will generate about 83,000 lb. of steam at 625 lb., 750 deg.

Air-Water Economizer Tempers Preheated Air

Much interest has been aroused by the arrangement of economizers at Stanton, in which the high pressure air-water economizer absorbs heat from the preheated air instead of from the flue gas as usual. The purpose of this arrangement was to enable the air preheaters to recover as much heat from the flue gas as possible, at the same time permitting the economizers to have their usual effect of flattening the efficiency curve and also to eliminate economizer tube corrosion. The economizer is built with fin tubes, like a generator air cooler but

designed for the high pressure. Since the economizer tubes have evaporated water on the inside and practically clean air on the outside, it is felt that there should be no trouble on the score of corrosion. Another advantage of the scheme is that the air-water economizer tempers the preheated air supply, keeping its temperature just low enough to prevent mechanical troubles in the stokers.

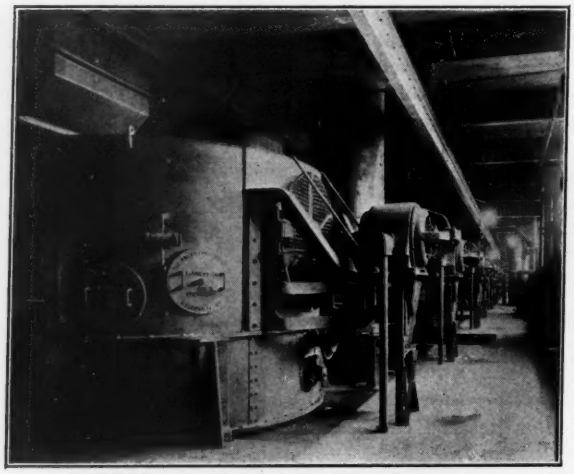


FIG. 5. EACH BOILER IS SERVED BY TWO ROTARY-ELEMENT TYPE AIR PREHEATERS

Rotary-Element Type Preheaters Used

Each boiler is served by two rotary-element type air preheaters of 40,500 sq. ft. heating surface each. When the boiler is delivering 175,000 lb. of steam an hour, flue gas leaves each boiler at about 750 deg. and passes to the two air preheaters which reduce its temperature to about 310 deg. These preheaters are designed to heat the air to about 525 deg. and force it down through a duct to the air and water economizer, of 3011 sq. ft. heating surface, which is set near the boiler room operating floor. This economizer further reduces the air temperature to about 380 deg. and it then passes to the air zones under the chain grate stokers. At the same time, the economizer is designed to raise the temperature of the incoming boiler feed water from 203 deg. to 245 deg.

Water piping for each economizer is arranged with a bypass line around the economizer and suitable throttle valves, so that, as the boiler output varies, the amount of water flowing through the economizer can be varied to give a practically constant temperature to the preheated air going to the stoker.

Draft is supplied to each boiler by the fans incorporated in the air preheaters. Each preheater has a forced draft fan and induced draft fan, both driven from the same 175-hp. motor, which also drives the rotary element of the preheater. For each boiler, therefore, there are two forced draft fans, designed to handle together 67,500 c.f.m. of air at 80 deg. when the boiler is making 175,000 lb. of steam an hour and two induced draft fans to handle together 112,500 c.f.m. of flue gas at about 310 deg.

Since the forced draft fan and induced draft fan of each preheater are mounted on the same shaft, driven by one motor, any speed change affects both fans equally. It is necessary, therefore, to use the dampers for regulation. To secure such regulation rapidly and accurately, motor-operated dampers are used for the main flue gas outlet in the uptake, between boiler and soot hopper. These dampers are remotely controlled by push-buttons on the boiler control board but are not automatic.

Soot blowing is done with compressed air at about 100 lb. pressure, instead of with steam. This is similar to the process used at Columbia Station.

Steam Extracted from Turbine Heats Feed Water

Feed water is heated by steam extracted from two stages of the main turbine, supplemented by the gland steam. Condensate from the condenser hotwell goes first through the generator air coolers, thence through the steam jet air pump condensers, low stage heater, gland steam condenser, deaerator condenser, open heater, deaerator and then to the feed pump. The latter forces it through the air-water economizer to the boiler.

Each battery of boilers is served by two centrifugal boiler feed pumps, a motor-driven unit for regular operation and a turbine-driven unit for standby. Each pump has a capacity of 800 g.p.m. against a head of 800 lb. Each pair of pumps is placed in the turbine room of the unit it serves. This was done primarily so that the pumps can be supervised by the turbine operators. For this purpose, a control board in the turbine room carries controls for the pumps, water level gages, recording thermometers and other instruments to give complete control of boiler feed water, makeup water, extraction steam and other necessary factors. These are all related directly to the operation of the turbine and the centralized control is valuable for this reason.

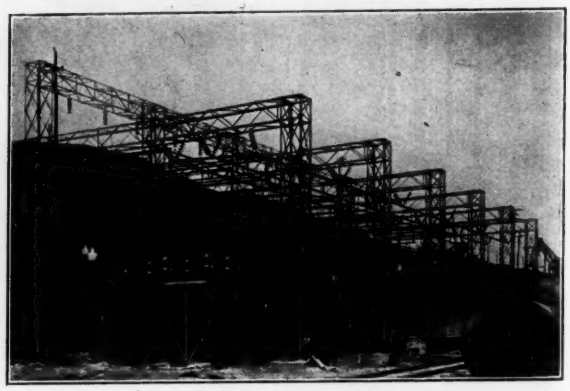


FIG. 6. ONE OF THE TWO SEPARATE 66-KV. SWITCH YARDS WHERE ALL HIGH TENSION SWITCHING IS DONE

Makeup water is taken originally from the river, although water from deep wells is also available. River water is pumped to the quadruple effect evaporator which has a capacity of 40,000 lb. of distilled water an hour. After evaporation it is stored in 7 tanks in the boiler room sub-basement, each tank holding about 42,000 gal. Evaporated water is also stored in a 100,000-gal. steel tank on a tower in the yard. From all these tanks the makeup pumps can send the water to

the open feed-water heater or else it can be supplied as cold suction for the boiler feed pumps.

A second 100,000-gal tank in the yard is filled with water from deep wells for general service and this water can also be sent to the evaporators for makeup, or to the open heaters in emergency.

To prevent venting of steam to the atmosphere from any apparatus, all water and steam drains in the station are run back to a receiver tank something like an open heater. Makeup water is sent to this tank where the temperature of the mixture of returns and cold water is kept just below 212 deg. by automatic temperature control. This mixture is then sent to one of the 42,000-gal. basement storage tanks, which is reserved for this purpose, and a separate makeup pump sends it from there up to the feed-water heater. This supply is used as primary makeup water; in case the amount of this should be greater than the demand, it is recirculated by means of the overflow on the open heaters back to the makeup receivers and drained to storage as before.

Turbines are rated at 45,000 kw. each, taking steam at 600 lb. at the throttle, 725 deg. total temperature. These units are of a single-cylinder 19-stage design. The entire volume of steam, at about 480 deg. is taken from the 7th stage, reheated at 160 lb. gage to 725 deg. and returned to the 8th stage. Steam for feed-water heating is extracted at the 16th stage at 6.8 lb. absolute pressure for the low pressure extraction heater, steam at 25 lb. abs. is extracted for the open feed water heater and the steam from the high pressure gland, at atmospheric pressure, goes to the gland condenser.

Single Pass Condensers Have One Floating Head

Condensers for these units have 35,000 sq. ft. of surface and are of a recently developed direct-flow, single-pass type, with one floating tube sheet; the unit is supported rigidly with a water-sealed expansion joint between turbine and condenser. Condenser tubes are arranged in straight lines converging in the direction of steam flow. Water inlets and outlets are provided at both ends so that the direction of water flow may be reversed to remove debris from the tube sheets. Non-condensible gases are removed from the lower portion of the shell and passed through an external, fin-tube, air cooler to the steam jet air pump.

Condenser tubes are rolled into the tube sheet at both ends, one tube sheet being fixed, the other being supported on sliding brackets and sealed around the edge by a rubber expansion joint similar to those often used to connect condensers and turbines. This construction was devised to eliminate packing and at the same time to prevent leakage. Since the Susquehanna River, from which Stanton takes its circulating water, is contaminated by the neighboring mines, a small amount of leakage into the condensate might give trouble.

The steam jet air pump is of the three-element, two-stage type. Each element can be isolated so that only the proper number necessary to remove the air need be used. Also any element can be repaired without taking the unit out of service. Steam for operating these pumps is extracted from the 6th stage of the main turbine at 185 lb. gage (full load pressure).

Circulating water is drawn from the Susquehanna River at the cribhouse through traveling screens and passes to the circulating pumps through concrete tunnels. Each condenser is served by a 72,000-g.p.m. centrifugal circulating pump, driven by a 2-speed motor rated at 450 hp. at 275 r.p.m. and 240 hp. at 200 r.p.m. These circulating pumps are not located under the condensers but are in a pump room at the north end of the turbine room basement, where the intake tunnels enter the building. These tunnels enter at the center line and branch to right and left, parallel to the plane of Fig. 2. From these branches, the circulating pumps take their suction and discharge into the tunnels shown on Fig. 2 as circulating pump discharge tunnels. These are so laid out that in the ultimate plant, one pump discharge tunnel will serve two condensers in each section, while there will be a circulating pump installed for each condenser. In other words, on each side there will be two

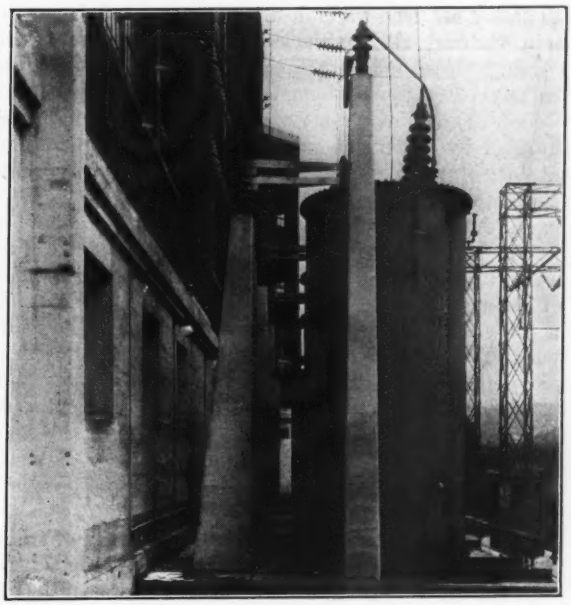


FIG. 7. EACH GENERATOR IS CONNECTED TO A BANK OF TRANSFORMERS JUST OUTSIDE THE STATION. NOTE GENERATOR LEADS TO TRANSFORMER IN CONCRETE DUCTS

circulating pump discharge tunnels, each supplying two condensers at one end and being served by two circulating pumps at the other end.

In effect, these form pressure tunnels, to which the inlet pipes of each condenser are connected. As there is an inlet and discharge pipe on each water box, a simple manipulation of valves will reverse the flow through the condenser. The condensers discharge to other concrete tunnels leading back to the river downstream from the intake. Since the circulating pump discharge tunnels and condenser discharge tunnels run parallel to the center line of the turbines, in the same direction in which the plant will be extended, they can be extended easily to serve the ultimate plant.

Besides the two circulating pumps, an ice melting pump of 72,000 g.p.m. capacity is installed to recirculate discharge water to the cribhouse. This ice melting pump is driven by a single-speed 450-hp. 275-r.p.m. motor and is arranged for ultimate use as a circulating pump. The tunnels are arranged so that one pump can pump into two tunnels and in winter, when the circulating water is cold, can serve two turbines. For this reason the two-speed pumps were installed, although they will not be used for all the future units.

House Generator Is Mounted on Main Turbine Shaft

Each turbine drives the following units, all mounted on the main shaft; a main generator rated at 45,000 kw. and generating at 11,000 v., a 250-kw., 250-v. main exciter; a 2300-kw., 2300-v. house generator; a 35-kw., 250-v. exciter for the house generator.

Cooling air for main and house generators is supplied by external fans of the overhung impeller type with cast-iron housings. There are four fans per generator, installed as shown in Fig. 2. Air is cooled with fin-tube coolers, the fans being used to give positive air circulation.

Use of the house generator and methods of handling auxiliaries form unusual features of this plant. Since the steam for feed-water heating is extracted from the main turbine, all auxiliaries in the plant are motor driven. These motors are all a.c. machines except for the motors of the coal-handling crane and the stoker motors. These are d.c. motors, those for the crane being supplied by motor-generator sets in the coal-handling substation and those for the stokers by motor generator sets in the boiler room.

All auxiliary squirrel-cage motors start direct across-the-line at 2300-v. The house generator supplies power to a group of iron-clad oil switches, from which all these auxiliaries are handled. This eliminates all motor compensators and starting devices and permits a simplification of auxiliary circuits that is economical and dependable. This is one of the first major installations of these iron-clad switches that has been made in this country.

To supply 2300-v. auxiliary power in case the main turbine should be shut down, a 69,300/2300-v. auxiliary transformer is provided.

Each main generator feeds direct to a bank of transformers outside of the station on either side, Fig. 7. No high voltage switching is done inside the station. Outdoor oil circuit breakers are located, with their disconnects, lightning arresters and other protective equipment in a switchyard, Fig. 6, on either side of the building, and all are remote controlled from an operating room at the north end of the building on the second floor.

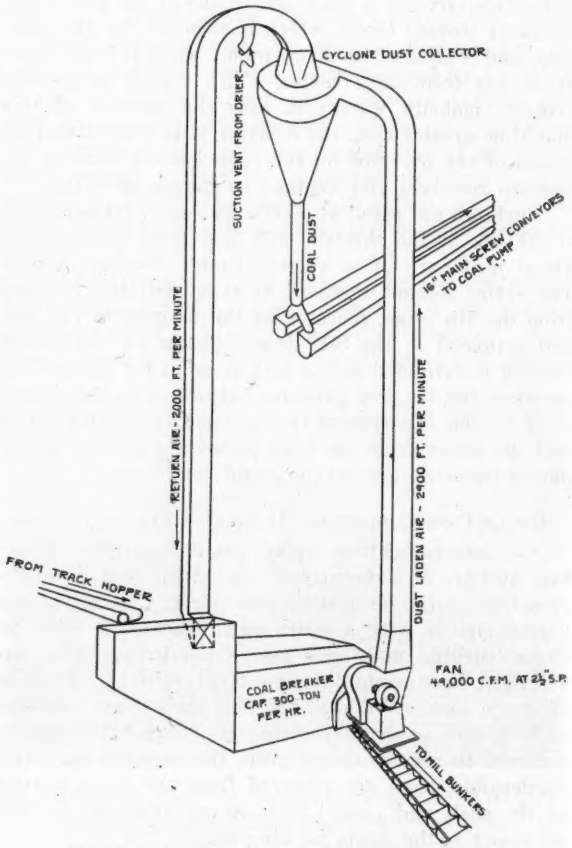
The north end of the building contains offices, battery rooms, storerooms, the main control room and all the equipment necessary to the operation of a great plant for producing and selling electric power at wholesale. Complete machine shop and electric shop equipment is provided in spaces at one end of each turbine room, so that work can be handled by turbine room cranes, while large turbine parts can be brought into these shops on standard railroad cars. Railroads tracks are also run into the boiler room basement below the firing aisle. On this aisle two 15-t. traveling cranes have been installed for general service, with hatchways in the floor through which to handle material from railroad cars below.

Stanton Plant was designed by Sargent & Lundy, Inc., Chicago, Ill., in conjunction with the engineering staff of the American Gas & Electric Co., of which George N. Tidd is president. A great deal of credit for the design is due to E. A. Johnsen, late chief mechanical engineer of the American Gas & Electric Co., whose untimely death last May was a great loss to his organization and to the engineering profession.

Coal Dust Collector Proves Money Saver

System Installed on Coal Breakers at Trenton Channel. By James N. Livermore

PULVERIZED coal exclusively is used for fuel in the Detroit Edison Company's Trenton Channel power plant. In being prepared for the burners, the green coal is first fed into a Bradford breaker where it is broken into lumps not over 1¼ in. in diameter. From here, a bucket conveyor elevates the coal to bunkers


CYCLONE DUST COLLECTOR
SUCTION VENT FROM DRIER
COAL DUST
16" MAIN SCREW CONVEYORS TO COAL PUMP
RETURN AIR - 2000 FT. PER MINUTE
DUST LADEN AIR - 2400 FT. PER MINUTE
FROM TRACK HOPPER
COAL BREAKER CAP. 300 TON PER HR.
FAN 49,000 C.F.M. AT 2½" S.P.
TO MILL BUNKERS

COAL DUST REMOVING AND COLLECTING SYSTEM

which feed it down through dryers to the pulverizing mills.

This breaker consists of a large steel case inside of which is a steel drum 12 ft. in diameter and 22 ft. in length, perforated with holes 1¼ in. in diameter. Inside the drum are lifting shelves which drop the coal from one side to the other as the drum revolves. At a rate of 14 r.p.m. each breaker has a capacity of approximately 300 t. per hr.

When the plant was first put into operation, difficulty was experienced with the Bradford breakers clogging with coal dust, and an excessive amount of dust being released into the room at the point where the breaker discharged into the bucket conveyor. The procedure followed to remedy this condition is shown in the accompanying figure. A fan capable of handling approximately 49,000 c.f.m. at 2½ in. suction pressure was chosen, and its suction was connected to the bottom side of the breaker housing near the discharge chute.

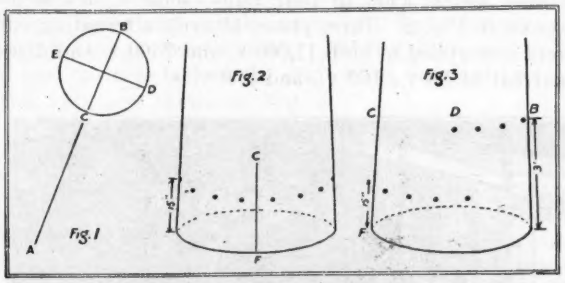
The fan discharge was connected to a cyclone dust collector, and the return air duct from the collector was connected to the inlet chute at the end of the breaker housing. The dust collector was located in such a position that the coal recovered could be discharged direct to the main screw conveyors which supply the boiler house coal pumps. A vent pipe will be noticed in the down bend of the return air duct. This vent connects to the dryers which are kept below atmospheric pressure by another exhaust system. The suction introduced in the return air duct prevents a positive pressure being created at the inlet end of the breaker, and actually keeps it at about atmospheric pressure.

This arrangement proved highly successful when put into operation. Not only was the dust nuisance at the breaker discharge eliminated, but it was found that roughly 4½ t. of pulverized coal per hr. was being recovered on each breaker, which could be fed to the furnaces without being milled. The two breakers operate from 8 to 10 hr. a day and the 72 to 90 t. of coal ready for the burners, collected here in that time, amounts to a real economy.

Razing Brick Stacks with Dynamite

OLD STACKS CAN BE DEMOLISHED BY AN EXPERIENCED MAN USING DYNAMITE AT A FRACTION OF THE COST NECESSARY WITH HAND LABOR

DISPOSING of an old stack, especially if it be surrounded by factory buildings, is a task not to be undertaken lightly. In a recent issue of the Du Pont magazine, the method used for accomplishing this difficult feat with dynamite is described in some detail.



FIGS. 1, 2 AND 3. DIAGRAM ILLUSTRATING THE METHOD OF CUTTING OUT AND BLOWING THE HOLES IN A STACK PRELIMINARY TO FIRING THE EXPLOSIVE

After determining the position most advantageous for the stack to fall, as line AB in Fig. 1, the center of the stack is estimated and a vertical line drawn on the stack to point C, as shown by CF in Fig. 2, and the points D and E are marked on a diameter at right angles to AB, then a row of holes is drilled about ¾ through the thickness of the stack at its base, so that the two center holes will be an equal distance from C and the end holes will be slightly beyond the diameter DE. This row of holes is intended for the explosive.

Another row of holes is then drilled clear through the stack higher up from the base, and on the opposite side, as DBE in Fig. 3. These are called cut holes. They are not to be loaded, but intended to weaken the wall and form a line of cleavage around that half of the stack.

When the drilling is completed, the two center holes are loaded and fired together by means of electric blasting caps. This makes an oval shaped opening in the stack, after which the next two holes on each side of the opening are fired, and so on, working in both directions until only two holes are left on each side. This operation is well illustrated in Fig. 4, with the row of loading holes visible on the right hand side of the stack. The last four holes are fired together, to give a violent shock at the same instant that the balance of the stack is destroyed.

Recently a 150-ft. stack hedged in between a store house and reservoir was dropped in an unrecognizable heap, 65 min. after the first shot was fired. The stack was located only 9 ft. from a new one, and several buildings were within a 60-ft. radius, the nearest one being only 10 ft. distant. The stack was thrown in a narrow opening between two buildings and but 5¼ lb. of explosive was required in the seven weakening shots and the final blast.

FIG. 4. LOADING A HOLE FOR A WEAKENING SHOT

JUST WHAT is the holding power of a given wood screw is a problem that has been definitely and accurately solved, probably for the first time, by the United States Bureau of Standards. The solution to this problem has been made possible by the long series of tests involving more than 10,000 screws of varying types, kinds and sizes, and seven or eight kinds of wood. And in conducting these studies Messrs. Aronowsky and Fairchild also took into consideration various other factors such as lubricants, lead holes, etc.

REPRESENTATIVES of public service corporations met with biologists recently at the Geneva (N. Y.) State Experiment Station to discuss the use of electric light as an aid to destroying harmful insects. An effort is being made to determine what sort of lighting is most effective to attract insects in order that they may be destroyed.

Firestone Remodels Furnaces for Pulverized Coal

INCREASING STEAM DEMANDS OF FIRESTONE TIRE & RUBBER CO. AT AKRON, OHIO, ARE MET WITH SAME BOILERS BY CHANGING FURNACES TO BURN PULVERIZED COAL, PREPARED BY CENTRAL SYSTEM

ABOUT FOUR YEARS ago the Firestone Tire & Rubber Co. at its great plant at Akron, Ohio, found it necessary to add to its steam generating capacity and to generate steam and power more efficiently than it had been doing.

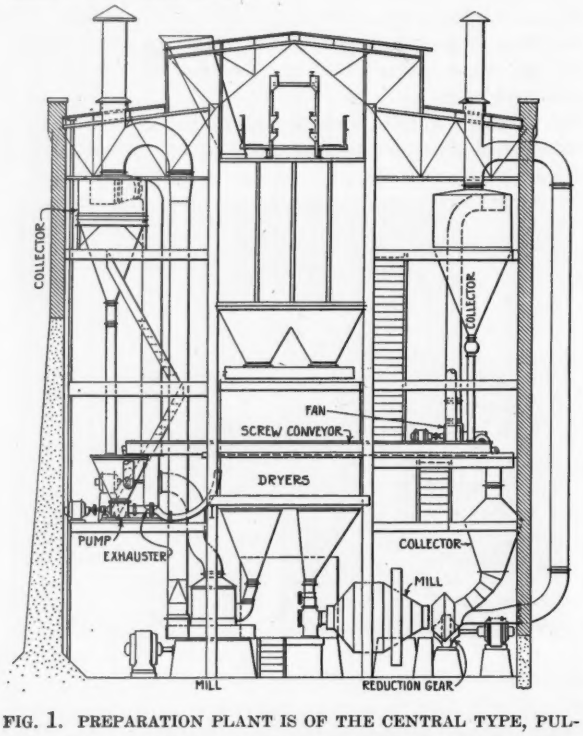


FIG. 1. PREPARATION PLANT IS OF THE CENTRAL TYPE, PULVERIZED COAL BEING AERATED AND PUMPED TO BOILERS BY SCREW PUMPS

Remodeling of the boiler house became necessary and three of its existing boilers were equipped with furnaces designed to burn pulverized coal. These boilers operated with great success, having a maintenance cost 43 per cent lower per boiler horsepower than that of the stoker-fired installation they replaced, and having an average furnace efficiency of 79 per cent. This record was so satisfactory that the company is now proceeding with the remodeling of all furnaces to burn pulverized coal.

A preparation plant of the central type has been built and up to date, 14 of the 20 existing boilers have been remodeled. Since these units are now operated at an average of about 250 per cent of rating, giving a considerable increase in capacity over the old boiler room, future conversions will be governed by the developments and demands of the manufacturing departments.

Figure 3 shows the Firestone power plant, which supplies the tire plants and subsidiaries with electric power, and steam, air and water for process work. Steam is generated at two pressures: 250 lb. 150 deg. superheat for the prime movers and 190 lb. saturated for process work. Three different air pressures, 20, 100 and 250 lb., three hydraulic pressures, 250, 500 and 1000 lb., and high-pressure circulating hot water must be maintained. Refrigeration service is provided for various departments, together with service water from deep wells; a pumping station and a 20,000-g.p.m. spray pond are installed at Summit Lake, about half a mile from the plant. The station has a power capacity of almost 40,000 kv.a. in four units, some of which are shown in Fig. 2. Three-phase, 60-cycle alternating current is supplied at both 11,000 v. and 2300 v. and direct current at 90 v., 160 v., and 250 v.

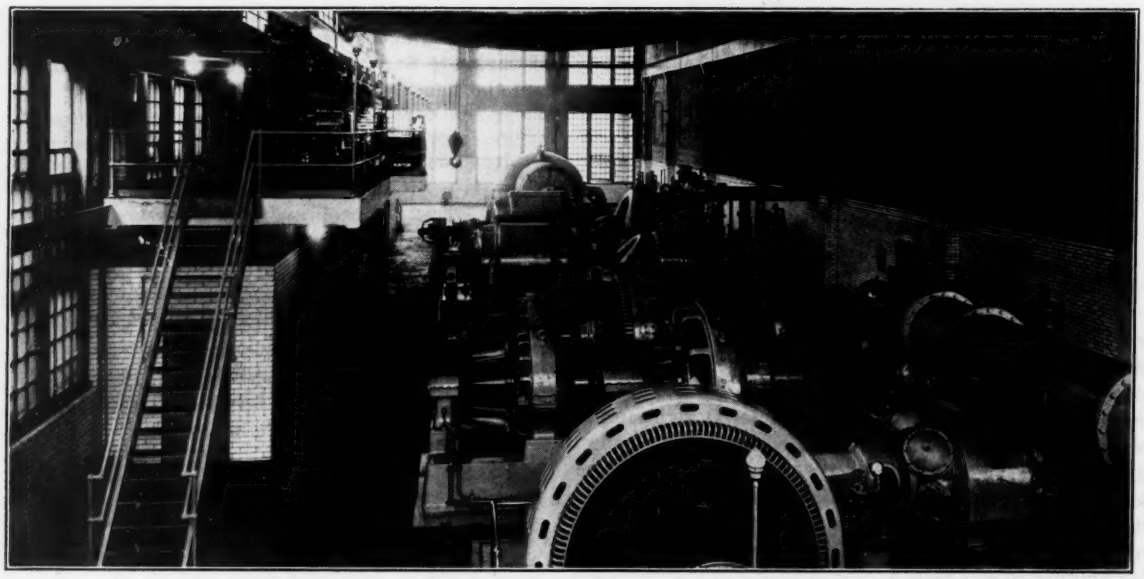


FIG. 2. STEAM TURBINES WITH TOTAL CAPACITY OF 40,000 KV.A., AIR COMPRESSORS, PUMPS AND OTHER EQUIPMENT ARE INSTALLED IN ATTRACTIVE TURBINE ROOM

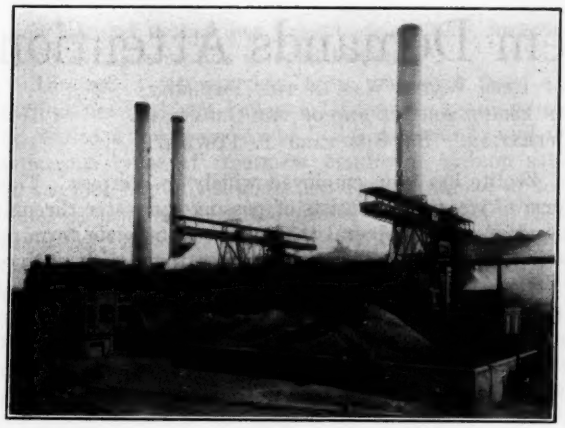


FIG. 3. EXTERIOR OF POWER PLANT SHOWING COAL STORAGE AND PREPARATION HOUSE AT LEFT

FIG. 4. FRONT WALL OF A PULVERIZED COAL FURNACE

In the boiler room before the changes were made, 20 V-type water-tube boilers were installed having a total rated capacity of 16,750 b.hp. and using approximately 1000 t. of bituminous coal a day. These were fired by underfeed stokers with comparatively low settings. In changing over to pulverized coal, it was found impossible to raise the boilers so the space formerly occupied by ash pits was used for the new furnaces, some additional excavation being needed to get the proper depth.

Figure 5 shows a section through one of these furnaces, the walls of which are water-cooled except for the front wall which is air-cooled. These walls were designed and built by the company's engineers. The water tubes are embedded in ordinary furnace brickwork and are connected with the circulating system of the boiler, as shown. Secondary air for combustion is brought in through the dampers in the front wall. Primary air is brought in through a jacket around the boiler breeching, being heated to about 250 deg. Natural draft only will be used on these boilers, the draft being supplied by the brick chimneys shown in Fig. 3.

In an entirely separate building is located the pulverized coal preparation equipment, Fig. 1, consisting of three 6-t. mills and three 15-t. mills with their auxiliaries. This use of a central system is somewhat out of the ordinary for an industrial power plant. After the conveyors have elevated the coal to the raw coal bunkers, it passes down through the steam dryers, the moisture being reduced by 4 per cent. The coal is pulverized to a fineness of 80 per cent through a 200-mesh screen, is taken from the mills by exhausters, passed through cyclones and then is pumped by screw pumps to the storage bins in the boiler house. A complete automatic control and signal system operates the various valves on the coal transport lines. To reduce dust to a minimum and eliminate chances of explosions, a vacuum cleaning system is being installed here and the inside walls are to be painted white.

Coal is fed to the fantail burners, which are set vertically in a flat suspended arch as shown, by screw feeders, where the primary air is introduced. These feeders are driven by variable speed d.c. motors. Each furnace has a volume of 5 to 5½ cu. ft. per rated horsepower.

Control of boilers is by steam-pressure regulator which varies the speed of the coal feeders while a master regulator proportions the load on all the boilers. A damper regulator controls the stack damper to keep a constant steam-flow-air-flow ratio. Each boiler is provided with a meter panel, Fig. 4, carrying steam-flow-air-flow meters, draft gages, flue gas temperature recorder and pressure gages, together with provision for switching from automatic to hand control.

All remodeling was done under the supervision and from the designs of R. R. Jones, chief engineer, and H .K. Jennings, power engineer.

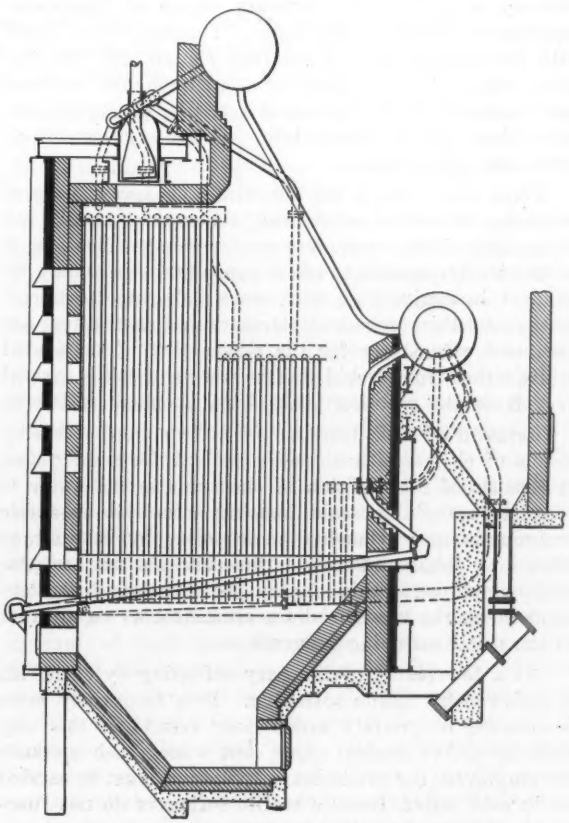


FIG. 5. FRONT WALL OF NEW FURNACE IS AIR COOLED, SIDE AND BRIDGE WALLS ARE WATER COOLED

Boiler Feed-Water Problem Demands Attention

SPECIFIC KNOWLEDGE OF THE TREATMENT OF FEED WATER WAS IN THE TWILIGHT ZONE BUT IS RAPIDLY BEING RECOGNIZED AS AN EXACT SCIENCE AND OF THE GREATEST IMPORTANCE IN POWER PLANT DESIGN AND OPERATION. BY SHEPPARD T. POWELL*

GREATER economy in the design and operation of steam generating equipment has been in the past and still is the impelling motive responsible for the rapid improvement that has taken place in the field of steam engineering within recent years. Radical changes in boiler and furnace design, higher steam pressures and temperatures and improvement in the design of prime movers have focused attention upon feed-water treatment. As a result of these conditions, a properly designed feed water make-up system is now recognized generally as a necessary and important factor in steam generation.

Good water is a relative term and may not be easily defined. Water of satisfactory quality for one purpose may be entirely unsuitable for a dissimilar service. This holds true not only for water employed in the various industries, but when it is to be used for boiler feed water. An ideal water for steam making use should contain no scale forming solids, should not cause priming or foaming and should be non-corrosive. The degree of purification desired depends entirely upon operating conditions, and the problem resolves itself into an economic balance between the cost of treatment and the ultimate return on the investment.

Removal of the suspended and soluble solids and the removal of gases is the primary object of feed-water purification outside of the boiler. The engineer is faced with the difficult task of determining not only the relative values of the numerous appliances and systems now available to accomplish this result, but must consider their specific adaptability under a given set of operating conditions.

Plain subsidence is the oldest and cheapest means of removing suspended solids and, although it should not be considered as a complete feed water purification, it is frequently possible to effect considerable economy by using it in conjunction with more elaborate treatment. Mechanical thickeners and clarifiers and sand filters are also used extensively for the elimination of suspended solids, either from turbid surface waters or solids carried over from the reaction tanks from chemical softeners.

Removal of scale forming solids from feed water by means of chemicals has been practiced for some years, It consists of the addition of chemicals to the water to convert the soluble scale forming salts into insoluble compounds and removing these solids by settling or filtration. Lime and soda or lime and barium are generally employed in this country, the only recent development being the use of sodium aluminate as an adjunct to the usual softening reagents.

At a few plants preliminary softening by chemicals is followed by zeolite softening. It is frequently more economical to produce satisfactory results in this way than by either method alone, but where such methods are employed, the preliminary treatment must be carried on in cold water, because zeolite softeners do not function satisfactorily with hot water.

*Chemical Engineer, Baltimore, Md. From a paper presented before the A. S. M. E. Regional Meeting at Kansas City.

Zeolite has been employed widely in the past. This form of treatment consists of passing the water through a bed of zeolite mineral that extracts the scale forming solids from the water and replaces them with sodium salts. After a given amount of sodium is exhausted from the mineral bed and replaced with calcium or magnesium from the water, the unit is cut out of service and the exhausted sodium replaced by sodium chloride or common salt solution. Zeolite softeners are of practically the same design as pressure filters in which the filter medium is replaced by the zeolite mineral.

In modern high-pressure plants the feed water should be as free from solids as is possible. Theoretically water from the evaporator should contain no soluble or suspended solids. This condition is seldom obtained, however, in practice. Distillate from evaporators will usually contain from ¼ to 1 grain per gallon of solids. Considering, however, that the percentage of makeup is usually from 2 to 4 per cent of the total feed water, no difficulty from scale forming solids from this source is probable. From an economic standpoint it is difficult to warrant the use of evaporators where the percentage of makeup is in excess of 20 per cent of the total volume of feed water.

Experience in steam engineering has demonstrated the importance of complete deaeration of feed water, in order to inhibit corrosion of boilers and appurtenances and to insure efficient surface condenser operation. It is well known that oxygen and carbon dioxide gas, two gases generally present in all mineral waters, are active accelerating agents of corrosion. When scale forming solids are removed from the feed water by external treatment, the tubes and sheet of the boiler may be less entirely free from scale and, under these conditions, gases coming into direct contact with the metal set up active corrosion.

Open feed-water heaters and chemical treatment of feed water that is carried out in hot solution, effect a fair removal of the gases, although not sufficient to make the installation of deaerators or deaerating heaters unnecessary in many plants.

In an effort to achieve greater economy of boiler operation, attention has been directed lately to continuous blow-down schemes. A number of appliances for this purpose have been placed on the market within the last 2 or 3 yr. One system filters the blow-down water and returns it to the boiler without an appreciable loss of heat. At least two other systems utilize the heat of the blow-down to heat the feed water in specially designed heating exchangers. More elaborate systems in use in Europe use the blow-down water to heat the raw water in hot chemical softeners.

Much has appeared in the technical press recently concerning electrolytic processes for the inhibition of scale and corrosion in boilers, condensers and heaters.

A rather extensive investigation has just been completed at one of the large public utilities and although the system completely stops all scale formation in the drum of the boilers, the tubes scale up rapidly. The

same type of system has proved satisfactory, however, in inhibiting corrosion in open heaters.

Internal treatment has been employed from the earliest use of steam boilers. Under this heading may be classed a great variety of boiler compounds and the numerous types of treatment employing sodium salts. In the majority of instances, external treatment of feed water is preferable to the use of compounds. There are cases, however, where the direct application of chemical to boiler water is warranted, and with this form of treatment, if intelligently controlled, relatively good results are possible. The principal objection to the use of compound is the indiscriminate use of materials of unknown composition. Many of these products are useless and may result in serious operating difficulties.

Steam purifiers are also coming into use rapidly for the purpose of removing the moisture and solids from the steam by mechanical means. These appurtenances may not be considered the cure-all, but when employed in conjunction with proper feed water conditioning are of specific value.

It is surprising to find how little definite knowledge is available concerning the actual conditions responsible for priming and foaming. It is believed generally that sodium salts are responsible for all priming and foaming. These salts and other soluble compounds are undoubtedly contributing factors. Recent experimental investigations, however, have demonstrated that many other factors are of importance and may not be ignored. The nature and degree of fineness of the suspended solids, the ratio of the soluble to the suspended solids and many other items enter into the problem, while numerous structural and operating details are responsible in part for these conditions. Treatment of the feed water may inhibit the tendency to prime or foam or may increase this action. Removal of suspended solids improves conditions and increasing soluble salts, particularly sodium compounds under some conditions accelerates the phenomenon.

Corrosion of boilers and of similar equipment and to a lesser degree the embrittlement of boiler metal, are definite problems which cause much annoyance in some stations. These operating difficulties are complicated, involving not only the feed water, but numerous other factors. To what extent the feed water is responsible is not always apparent. Where such troubles are encountered, a careful investigation of all conditions should be made since a solution may be obtained only in this way. The more important single factor accelerating corrosion is oxygen, although the removal of oxygen from feed water may not completely inhibit corrosion, since other constituents in water are contributory agents, but the removal of oxygen will reduce merely the rate of corrosion in proportion to its specific effect.

Correcting the Heat Balance in a Sugar Refinery

In One Plant a Careful Survey Indicated That an Average of About 32,000 Lb. of Steam Per Hr. Could Be Reclaimed by Installing a Combination Mixed Pressure and Bleeder Type Turbine. By C. W. Shannon

CORN SIRUP and sugar refining plants have a large number of evaporating pans and are, of course, large users of low pressure steam. It is not possible to operate these pans on any fixed cycle, thus the amount of low pressure steam required varies within wide limits and is under no means of control. In our plant the turbines are equipped with an exhaust head set at approximately 5 lb. gage so that when the demand for 5 lb. steam falls off the excess is released to atmosphere with an attendant loss of heat. This condition is aggravated by the fact that when the pans are all in service there is a shortage of low pressure steam and the process work is slowed up until sufficient steam again becomes available.

To prevent this waste of steam to atmosphere and yet maintain an adequate supply of 5 lb. of steam to the evaporator has been a problem which we feel will be effectively solved by the introduction of a bleeder mixed pressure turbine. Our generating equipment at present consists of one 600, two 750, and one 1000-kw. non-condensing turbines ranging in age from 7 to 18 yr. As in many industrial plants the turbines merely serve as reducing valves giving low pressure steam for heating and evaporating and at the same time yielding power at a very low cost.

Determination of the amount of steam being wasted through the exhaust heads was made by the use of a steam flow meter. One of the larger heads was set to blow at 5 lb. gage and the meter installed on this line. The other heads were set a trifle higher. By this means it was found that our waste of exhaust steam varied from 0 to a maximum of about 50,000 lb. per hr. and under ordinary conditions of weather and grind would average about 32,000 lb. per hr.

Assuming a cost of 30 cents per 1000 lb. of steam, this would amount to approximately $230 a day. Aside from the waste of steam and condensate the prevention of this water being deposited on adjacent buildings was an important factor, especially in the winter time, since it takes the form of ice endangering roofs and power lines. In addition the fact that we needed an additional 1000-kw. turbine capacity influenced the decision to install a mixed flow-bleeder turbine somewhat, as it offered a method of solving both problems.

The first propositions offered by the turbine builders were all more or less unsatisfactory and lacking in important details, but after consultations and alterations each of the manufacturers proposed a unit that would meet our requirements. Each manufacturer was asked to supply the following information regarding the amount of high pressure steam required to generate 1000 and 500 kw. with maximum bleeding, 50 per cent bleeding, 25 per cent bleeding, straight condensing, use of 50 per cent of 5 lb. steam, use of 25 per cent of 5 lb. steam and 5 lb. steam only. By using these points curves as shown in Fig. 1 were drawn so that a comparison of the proposed machines could be easily made.

In this figure the vertical scale indicates the lb. per hr. of high pressure steam admitted at the throttle, while the horizontal scale to the right gives the amount

of steam it is possible to extract in lb. per hr. and the horizontal scale to the left gives the amount of 5 lb. steam that may be used in the turbine for the generation of power. Assuming a given quantity of steam admitted at the throttle and projecting horizontally to the right to the point of intersection on the curves, the quantity of 5 lb. steam that can be extracted may be read. The remainder, of course, goes through to the condenser in order to carry the specified load. Again, assuming a given quantity of 5 lb. steam available and projecting vertically to the intersection of the curve, the additional amount of high pressure steam necessary to carry the load may be read.

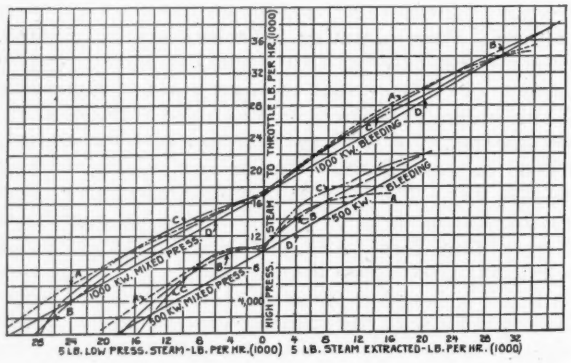

THROTTLE LB. PER HR. (1000)
HIGH PRESS. STEAM TO
1000 KW. MIXED PRESS.
500 KW. MIXED PRESS.
1000 KW. BLEEDING
500 KW. BLEEDING
5 LB. LOW PRESS. STEAM-LB. PER HR. (1000)
5 LB. STEAM EXTRACTED-LB. PER HR. (1000)

FIG. 1. A COMPARISON OF THE INITIAL PROPOSALS OF THE FOUR MACHINES WHEN GENERATING 1000 AND 500 KW.

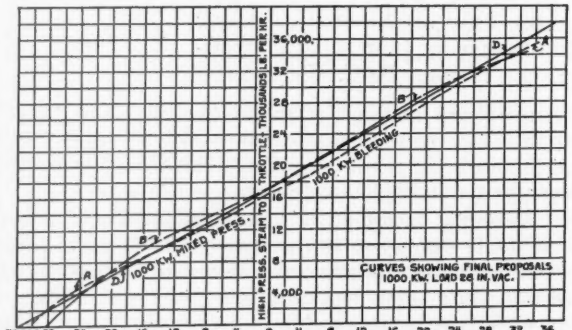

THROTTLE THOUSANDS LB. PER HR.
HIGH PRESS. STEAM TO
1000 KW. MIXED PRESS.
1000 KW. BLEEDING
CURVES SHOWING FINAL PROPOSALS
1000 KW. LOAD 28 IN. VAC.
LOW PRESS. STEAM LB. PER HR (THOUSANDS) STEAM EXTRACTED LB. PER HR.

FIG. 2. FINAL PROPOSALS FROM WHICH A MACHINE WAS SELECTED

After these comparisons had been made, one of the companies discovered that it had been quoting on a machine operating under a 27-in. vacuum while the others were quoting machines operating under a 28-in. vacuum. The final propositions are shown in Fig. 2. Any of the machines as indicated was satisfactory to meet our requirements. Machine A indicated a slight advantage in economy and was selected.

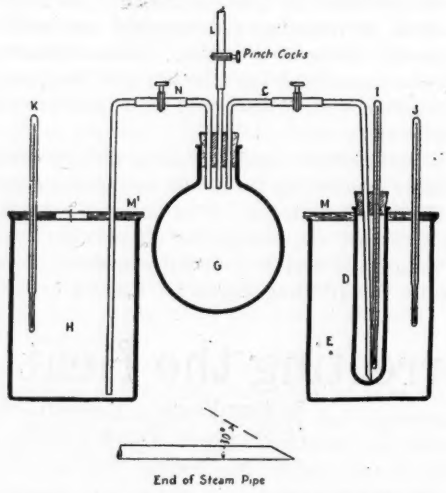
So far our proposed savings are theoretical but backed by the operation of somewhat similar units already in operation at other plants, we feel that the proposition will work out much as we have planned.

PROPER MAINTENANCE and adjustment of operating machines with adequate lubrication to insure minimum friction loss and wear is the only remedy for power plant ills.

Steam Emulsion Tests for Turbine Oil

TESTING turbine oil to determine the number of minutes required for an oil to separate when emulsified is described by the Standard Oil Co. in accordance with the A. S. T. M. method. Results of the emulsion tests are recorded in minutes and half minutes of time necessary for 20 c.c. of the oil to separate.

Apparatus necessary for the test is shown in the diagram herewith, and consists of a steam generator G, of at least one litre capacity, and capable of withstanding the heat necessary for continued generation of steam. It is fitted with three outlets: N to separating bath H, C to oil container D, and L to atmosphere.



APPARATUS USED IN STEAM EMULSION TEST OF OIL

Thermometers K, I and J indicate the respective temperatures of the settling bath H, the oil D, and the emulsifying bath, E. Pinch cocks are used to regulate the flow of steam through N, C and L, and the two baths have suitable covers to hold the various parts of the apparatus in position.

Baths H and E should have a capacity of 3 to 3½ litres, and a depth of 7½ to 9 in. The emulsification bath should be of glass, while the other can be either glass or metal. Each can be applied to the steam generator by electricity or gas. The oil container D, can be made from a 25 to 200 mm. test tube graduated from 0 or from 10 to 50 c.c.

The steam piping is best made from a piece of thin glass tubing not less than 2.3, nor more than 2.7 mm. inside diameter and 12 in. in length. The steam delivery tube to the oil container should be cut diagonally at an angle of about 30 deg. as shown at the bottom of sketch and should be bent at right angles about 10 in. from the bevelled end.

When starting the test, baths H and E should be filled with 3 litres, plus or minus 60 c.c. of water. The temperature of the separating bath H should be maintained at from 200 to 203 deg. F. while the temperature of the emulsifying bath E should be from 65 to 78 deg. F. at the start of the test, but need not be controlled thereafter; 20 c.c. of the oil to be tested should be put

in the test tube D at room temperature and D set in position as shown in the diagram. Considerable care must be exercised to see that the apparatus is clean chemically before using and that no foreign materials enter the steam generator.

Steam from the generator should be blown through the tubing N, L and C until all condensation disappears, at which time the thermometer should be placed in position, the tube C inserted in container D until its outlet touches the bottom of the test tube.

Steam should then be admitted through C at such a rate as to maintain the oil temperature between 190 and 195 deg. F. As steam is admitted through C, it will emulsify with the oil so that the volume in container D gradually increases. During this steaming process, the steam supply shall be sufficient so that it will cause a generous discharge through the line L. Steaming is continued until the volume of condensed steam and oil in the container D is 40 c.c. plus or minus 3 c.c. This should require 4 to 6½ min. If less than 12 min., the test should be re-run. The apparent volume in the container near the end of the test is, of course, 12 to 16 c.c. greater than the actual volume, due to the displacement caused by the thermometer in the steam delivery tube and due to steam displacement.

As soon as the required volume is obtained, the steam delivery pipe should be quickly withdrawn from D at the same time as stop-watch is started. D should then be transferred quickly to the separator bath H, which should be maintained at from 200 to 203 deg. F. until the end of the test. When the oil container is in place in the separating bath H, the cork and thermometer should be removed, at which time the oil and water will start to separate.

Every 30 sec. the volume of separated oil should be recorded, making no distinction between the clear and turbid oil. Oil which emulsifies separates into three layers, top, clear or turbid oil, middle, lacy or creamy emulsion; and bottom, clear or milky water. In removing the container for this reading, the minimum time should be required, and in no case should this exceed five seconds. If, at the end of 20 min. there is not a well defined separation, then and only then, the contents of the container may be stirred for 2 sec. with a clean glass rod to obtain a better line of demarcation. Results are reported in minutes and half minutes of time necessary for the 20 c.c. to separate. If it does not separate in 20 min. it is to be reported as 20 plus, but if duplicate determinations vary by more than 1 min., the average of three tests shall be reported.

Diesel Engines from Central Station Standpoint

DIESEL ENGINES HAVE A DEFINITE FIELD OF APPLICATION BUT A SUCCESSFUL INSTALLATION REQUIRES MORE THAN THE MERE PURCHASE OF AN ENGINE AND SOME OIL STORAGE TANKS. BY JOHN M. DRABELLE*

AT FIRST GLANCE, a Diesel engine with its apparently low B.t.u. consumption per brake horsepower-hour or per kilowatt-hour, when compared to some of the older forms of prime movers, would seem to offer a solution for all of the ills and troubles incident to the generation of power. There has been much discussion among central station engineers and marine engineers as to the practicability and adaptability of the Diesel engine to central station and marine service. Unfortunately a considerable amount of the advertising literature put out by manufacturers is somewhat misleading and unless a careful study of each and every situation is made it may lead to some wrong conclusions.

Much published information has been passed around on shop tests under the hands of skilled engineers and mechanics or the generation of power based on extremely high load factors. In central station practice, the load factor on the prime mover of 50 per cent is most unusual and this is particularly true of smaller plants supplying a small transmission net work, or a plant supplying an isolated community. It is true that good results in respect to kilowatt-hours per gallon of fuel oil are secured for a few hours over the evening peak but unfortunately there are some 20 other hours in the day to reckon with. A considerable number of these comparisons have been based on making a setup for the Diesel engine generating nearly double the kilowatt-hours the old steam unit used to generate and in many cases the old steam unit was the conventional low pressure Corliss engine with belted generator. Comparisons of this kind take on the form of trying to multiply oranges by pineapples and getting a result. The Diesel engine has a field of application and is a most excellent prime mover but like everything else it has a definite field of application.

This field may be stated to be (and this is based on operation of several plants over a period of several years): where water is difficult to secure in adequate quantities for condensing purposes and of poor quality for boiler purposes, where the cost of coal per ton is high, where the loads are relatively small and reliable transmission line service is not available due to extreme lengths of lines with attendant investment charges and fixed costs, or in that part of the country where fuel oil can be easily secured and at a favorable price.

There has been in the past a great lack of reliable operating cost data and also reliable data as to investment costs in Diesel engine plants based on a unit of kilowatts of installed capacity. Through the efforts of the accounting section and the Prime Movers Committee of the National Electric Light Association a common and comparable basis is now available for accounting for the plant performance and the plant investment and due to this system of accounts the data are now becoming rapidly available. Generation costs kept under such a system of accounts show a considerable increase as compared to the average reported costs in advertising literature.

When considering a Diesel engine station for power supply purposes some rather salient factors must be considered in addition to the mere purchasing of an engine and some oil storage tanks. The original design and set-up has a very direct bearing on future generating costs. Water supply for cooling the engine cylinders is of the most serious importance and should not

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in any case be taken for granted. A chemical analysis of the water should be made in every case and if it is found to have a tendency to form scale, some type of treating plant must be provided.

Silencers May Be Necessary in Towns or Cities

If the power plant is located inside the corporate limits of a city or town, there may be some objection to the exhaust and intake air noise from adjacent property owners and to eliminate this some form of silencer must be provided. To eliminate the possibility of transmitted vibration to adjacent buildings, heavy foundations must be provided.

In order to secure low bearing and cylinder maintenance together with low lubricating oil consumption, it is very desirable to provide the plant with some form of centrifugal apparatus for cleaning the lubricating oil. This equipment will take care not only of the dust that is present in the air, but the carbon that is formed on the cylinder walls.

In order to protect the cylinders and valve gear in dusty places particularly adjacent to the unpaved streets or other dust producing sources air filters should be provided. They will yield a good return.

Another common fallacy seems to be on the part of some manufacturers to state that anyone can operate and run a Diesel engine. Experience covering several years now seems to point out, at least to the writer, that a well-trained, well-paid and well-satisfied power plant crew of the same degree of intelligence or better is required for the operation of the Diesel plant as compared to a station of the same size operating steam engines or other forms of steam prime movers.

Power plant auxiliaries are often overlooked and the following eight points must receive careful consideration in laying out and designing the plant:

1. Cooling tower with its water reservoir.
2. Fuel storage tanks, and in cold elimates, proper heating coils for these tanks.
3. Fuel oil unloading pumps with their attendant piping and track pits.
4. Water circulating pump for jacket water. These must be in duplicate.
5. Water softening equipment for providing scale free water for the engine jackets.
6. A heating plant for the building.
7. Air compressors and air storage tanks. All of this equipment requires a large amount of high and low pressure piping with all of the usual valves and fittings that go with any piping job and in the end represent a considerable sum of money.
8. Properly to maintain and make repairs in the field, an adequate shop and shop facilities must be provided. A good screw cutting engine lathe, with the usual attachments and a post grinder is of great advantage in facing and refinishing valves, also a good drill press and a good emery wheel stand fitted with two wheels is particularly desirable equipment. With all of this goes the usual wrenches, vise, pipe threading tools, calipers, micrometers and the ordinary run of small machine shop and pipe fitting tools.

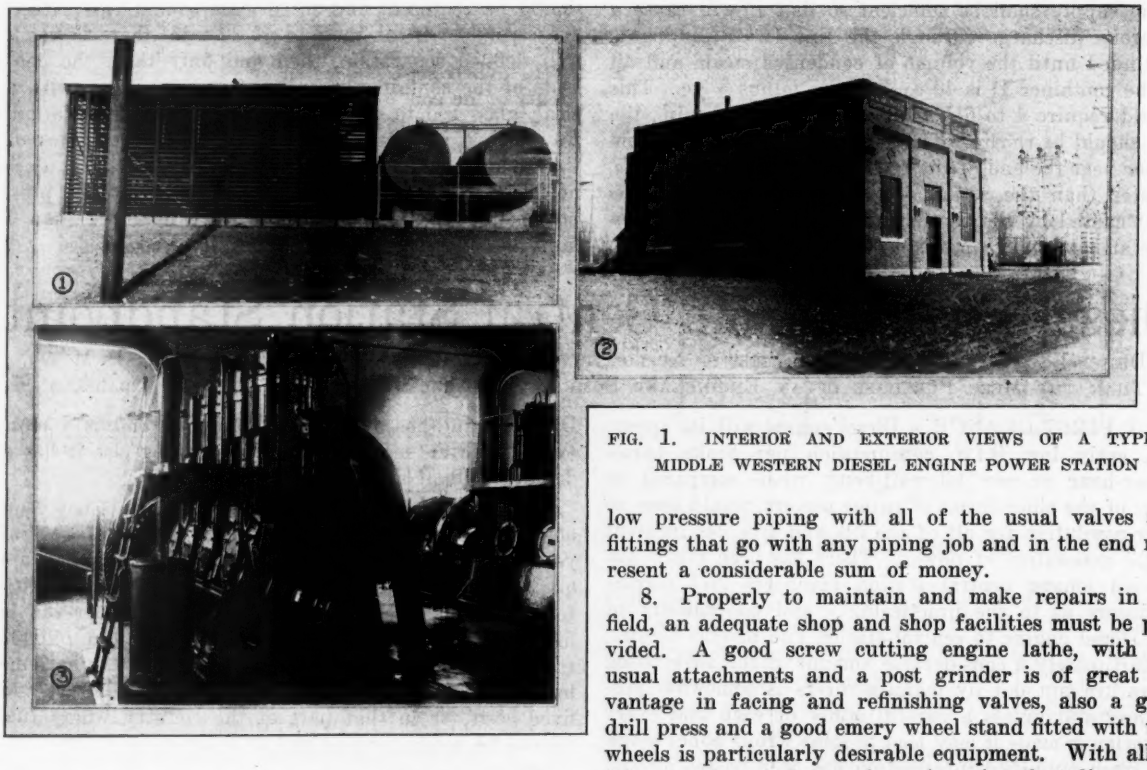


FIG. 1. INTERIOR AND EXTERIOR VIEWS OF A TYPICAL MIDDLE WESTERN DIESEL ENGINE POWER STATION

In treating any plant it is the total cost of power that must be considered and all of the costs must be included. Figures in Table I are believed to be conservative.

TABLE I. DISTRIBUTION OF FIXED CHARGES

Interest on the investment	8 per cent
Taxes and insurance	2 " "
Depreciation and obsolescence	8 " "
Total	18 " "

There may be some question as to the exact division of the above percentage charges. There are some cases where money can be secured for a somewhat lower figure but in the end a capital and fixed charge of from 15 to 18 per cent is the answer.

Form L-4—49 mis to pad—2M mis 1-27

Diesel-Generator Operating Log

Operator 1st Shift .....
" 2nd " .....
" 3rd " .....

_____ Company

STATION _____ Day Ending Midnight _____ 192

GENERATOR DATA

Generator Number	Engine Manufacture Name		Electric / Fuel Oil / Lub. Oil
Maximum Generator Amperes Stator	Started by	Unit on Line at M. Meter	
Maximum Field Amperes	Shut down by	Unit off Line at M. "	
		Total Generated	KWH / Gals. / Gals.

TEMPERATURES °F.	1 A.M.	2 A.M.	3 A.M.	4 A.M.	5 A.M.	6 A.M.	7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 N.	1 P.M.	2 P.M.	3 P.M.	4 P.M.	5 P.M.	6 P.M.	7 P.M.	8 P.M.	9 P.M.	10 P.M.	11 P.M.	12 M.
Inlet Cooling Water																								
Outlet Cooling Water Cyl. 1																								
" " " " 2																								
" " " " 3																								
" " " " 4																								
" " " " 5																								
" " " " 6																								
Pyrometer Cyl. 1																								
" " 2																								
" " 3																								
" " 4																								
" " 5																								
" " 6																								
Color of Exhaust																								
Outside Air Temp.																								
Water Pressure																								
Air Pressure—Starting																								
" First Stage																								
" Second Stage																								
" Third Stage																								
Engine Water Meter																								
Barometer																								
Soap Test																								
Oil Meter																								
Watt Hour Meter																								
GENERATOR OPERATION																								
Cycles																								
Volts. Phase "A"																								
Volts. Phase "B"																								
Volts. Phase "C"																								
Amperes. Phase "A"																								
Amperes. Phase "B"																								
Amperes. Phase "C"																								
Field Amperes																								
Kilowatt Load																								
EXCITER No.																								
Volts																								
Ampere Load																								

INSPECTION SCHEDULE
For Two-Cycle Engines

WEEKLY OR EVERY 150 HOURS OF OPERATION
1. Inspect and clean the exhaust ports.
2. Inspect the condition of the piston and rings, through the exhaust cover plates.
3. Check the feeds of the lubricator.
4. Blow out generator, exciter and pump motors.
5. Clean air filter.

MONTHLY OR EVERY 600 HOURS OF OPERATION
1. Inspect and regrind injection nozzle valves.
   Use the "Clover Leaf" brand of fine carborundum paste.
2. Inspect and clean the air suction valves.

QUARTER ANNUALLY OR EVERY 2000 HOURS OF OPERATION
1. Remove and inspect the crankpin bearing.
2. Pull pistons and clean them.
3. Clean out water jackets and remove scale.
4. Regrind all valves in injection and auxiliary fuel pumps.
5. Thoroughly clean the lubricating oil pump, crankcase, crankpin, oil ring, main bearing oil wells, mechanical force feed lubricator and fuel strainers.

SEMI-ANNUALLY OR EVERY 4000 HOURS OF OPERATION
1. Clean the exhaust pipes leading to conduit.
2. Inspect and clean water piping, circulating pump and the cooling equipment.

INSPECTION SCHEDULE PRINTED ON REVERSE SIDE OF EACH SHEET

INSPECTION SCHEDULE
Four-Cycle Engines

WEEKLY OR 150 HOURS OPERATION
1. Clean air filters.
2. Clean fuel oil filters.
3. Clean lubricating oil filters.
4. Purify lubricating oil.
5. Check inlet, exhaust, and spray valve cam clearances.
6. Blow out generator and exciter
7. Balance load on cylinders.

MONTHLY OR 600 HOURS OPERATION
1. Clean, repack, regrind spray valves.
2. Regrind exhaust valves
3. Inspect crank case.

QUARTERLY OR 2000 HOURS OPERATION
1. Regrind suction valves.
2. Regrind fuel pump valves, check fuel pump setting.
3. Regrind and clean air compressor valves.
4. Clean and test all relief valves.

YEARLY
1. Pull all main power pistons.
2. Take up on wrist pins.
3. Take up connecting rod boxes.
4. Take up main bearings.
5. Check crank shaft alignment.
6. Pull air compressor piston.
7. Clean governor.
8. Clean jacket water spaces and heads.
9. Test all gauges.

YEARLY INSPECTION BY MANUFACTURER'S ENGINEER.

CONDITION of FOLLOWING this date												
Air Pump No.		Oil Pump No.			Circulating Pump No.			Collector Rings		T. A. Rec.		
CLEANING	Date	Month	Year	Note: For cleaning, enter last date	Date	Month	Year	Note: Carry date forward daily.	Date	Month	Year	
Pistons Cleaned				Exhaust Ports Inspected				Generator Blown Out				
Heads Sealed				Oil Filter Cleaned				Air Filter Cleaned				

FOR INSPECTION SCHEDULE SEE REVERSE SIDE

Checked _____ Station Chief.

White copy Plant File. Yellow copy mail M. & R. Dept. C. Keep Clean and Write Neatly

FIG. 2. A COMPLETE RECORD IS KEPT IN THE POWER PLANT LOG WHICH HAS THE INSPECTION SCHEDULE PRINTED ON THE BACK OF EACH SHEET

There are considerable published data as to the investment charges on steam plants or, as sometimes termed, cost per kw. of capacity. For Diesel engine stations, not a great amount of reliable data has been available. A power plant recently erected contained two solid injection oil engines respectively 240 and 360 hp., direct-connected to alternating-current generators, with attendant switchboard and substation equipment, cost $89,916 or in terms of kilowatts of capacity installed $220. This cost segregated in Table II does not represent the maximum nor does it represent the minimum.

Fixed Charges Can Be Calculated

With the investment known, it is possible with the percentage Table I to compute, knowing the load factor, the fixed charges per kilowatt-hour. Assuming an investment of $250.00 per kw. of capacity installed with a station capacity factor of 30 per cent, these fixed charges are 17.1 mills. For a 40 per cent factor these are 12.8 mills and for a 50 per cent factor, 10.3 mills, the latter seldom being obtained in the small isolated central stations. The matter of maintenance costs of the Diesel engine is one around which the discussions have waxed the hottest. It is primarily due to the lack of proper accounting records that this discussion has taken the form in which it has. There has been considerable adequate and reliable information put forth by various manufacturers.

In order to have proper supervision and adequate inspection of Diesel engines, records are very desirable and particularly hourly records to show the various conditions as the load changes upon the engine. To this end a form known as the "Diesel-Generator Operating Log" shown in Fig. 2 was developed.

A tabulation of design details of Diesel engines will show a considerable difference between various manufacturers, particularly in regard to the two-cycle engines, of speeds, weights of flywheels and mean effective pressure per brake horsepower. Maintenance experience seems to show conclusively that the lower the mean effective pressure per brake horsepower becomes the lower the cost of cylinder head maintenance becomes in the two-cycle engine. There is a tendency on the part of some manufacturers to rate up these engines to the maximum limit of possible performance and apparently the horsepower ratings are based entirely upon factory performance and conditions under the supervision of factory men that are practically impossible to maintain under daily operating conditions. It is true that any engine can be tuned up and for a few hours give very

TABLE II. COST DATA 600 BR.HP. SOLID INJECTION DIESEL PLANT

	Cost	Cost per Kw.
Engine 240 hp. and 200 kv.a. generator	$15,510.00	$97.00
Engine 360 hp. and 300 kv.a. generator	21,795.13	90.70
Building, foundations, cooling tower and fuel oil tank piers	18,099.35	40.25
Pipe, pipe fittings	5,772.10	14.41
Electrical material	6,252.34	15.62
Miscellaneous material	296.88	.74
Auxiliaries (pumps, compressors, etc.)	2,934.86	7.42
Transportation (freight and express)	642.74	1.60
Stores and storekeeping	520.40	1.30
Labor	5,537.00	13.82
Insurance on labor	376.96	.94
Interest during construction	1,230.26	3.08
General engineering and accounting	3,128.66	7.82
Overhead	5,819.54	14.52
Real estate	2,000.00	5.00
Total cost	$89,916.33	

TABLE III. STATION "A" ENGINE CAPACITY 900 HP.

	Operating Cost	Cost per Kw-hr. in Cents
Kilowatt-hours generated (net) 833,071 kw-hr.		
Operating Costs:		
Maintenance	$ 1,100.45	.1321
Operation:		
Labor	4,509.27	.5413
Fuel	7,256.54	.8711
Water	192.05	.0230
Lubricants	670.80	.0805
Miscellaneous	568.29	.0682
Total operation	$13,196.95	1.5841
Total Maintenance and Operation	$14,297.40	1.7162
Gallons of oil consumed for fuel	114,063 gal.	
Average cost per gallon	$.063618	

STATION "B" ENGINE CAPACITY 600 HP.

	Operating Cost	Cost per Kw-hr. in Cents
Kilowatt-hours generated (net) 776,458 kw-hr.		
Operating Costs:		
Maintenance	$ 2,171.54	.2707
Operation:		
Labor	3,843.36	.4950
Fuel	6,614.39	.8518
Water	21.46	.0028
Lubricants	1,056.78	.1361
Miscellaneous	1,275.19	.1642
Total operation	$12,811.18	1.6499
Total Maintenance and Operation	$14,982.72	1.9296
Gallons of oil consumed for fuel	101,420 gal.	
Average cost per gallon	$.065217	

remarkable results, but day to day results, the month to month results and the average over the year are what finally count in the analysis of plant costs and reliability and continuity of service.

Operating statistics of two stations generating approximately the same amount of current are given in Table III and will be of interest: Station "A" consists of 900 hp. of engine capacity while Station "B" consists of 600 hp. of engine capacity. An analysis of the costs of operation is given. It will be noted that the fuel oil costs when equated to a proper load factor are within the ordinary published statistics of engine manufacturers. The lubricating oil costs, however, are considerably higher as are the maintenance costs.

Test Performance Gives Comparative Data

Performance under test conditions gives some indication as to what might be expected from daily operation and the curves in Fig. 3 are self-explanatory and show some interesting things pertaining to the performance of different types of engines. Test curves shown are from two radically different types of engine, namely the four-cycle air injection and the two-cycle solid injection. These units, however, are of different sizes and when making any comparisons this point must be carefully borne in mind.

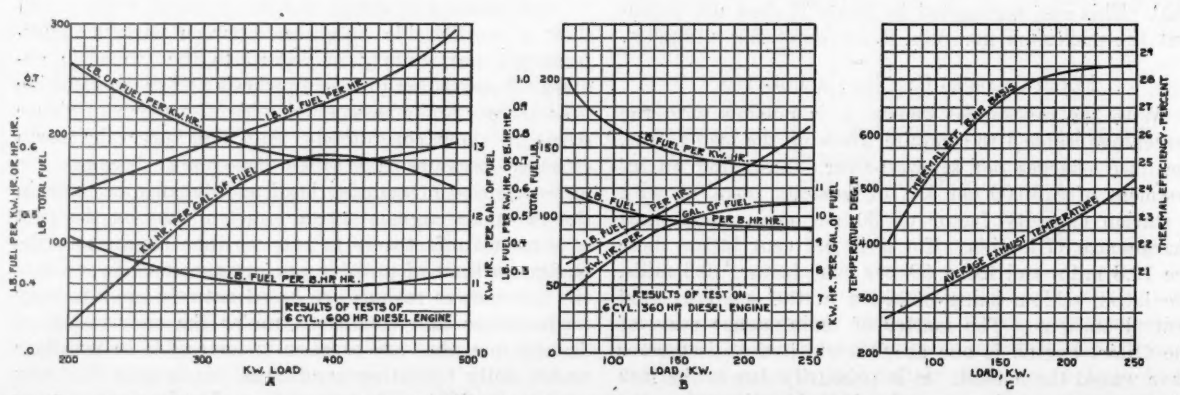

LB. OF FUEL PER KW. HR.
LB. OF FUEL PER HR.
KW. HR. PER GAL. OF FUEL
LB. FUEL PER B.HP. HR.
RESULTS OF TESTS OF 6 CYL., 600 HP. DIESEL ENGINE
KW. LOAD
A
LB. FUEL PER KW. HR.
LB. FUEL PER HR.
GAL. OF FUEL PER B.HP. HR.
KW. HR. PER GAL. OF FUEL
RESULTS OF TEST ON 6 CYL. 360 HP. DIESEL ENGINE
LOAD, KW.
B
THERMAL EFF. B.HP. BASIS
AVERAGE EXHAUST TEMPERATURE
THERMAL EFFICIENCY-PERCENT
TEMPERATURE DEG. F.
LOAD, KW.
C

FIG. 3. TEST RESULTS OF A SIX-CYLINDER 600-HP. FOUR-CYCLE AIR INJECTION DIESEL ENGINE, A, AND A SIX-CYLINDER 360-HP. TWO-CYCLE SOLID INJECTION ENGINE, B AND C

Much has been written as to the relative advantages and disadvantages of two-cycle and four-cycle engines of solid and air injection. No hard and fast rule can be laid down. The two-cycle solid injection has the inherent advantage of being somewhat simpler mechanically and in smaller plants this is of some advantage so far as the operating and maintenance crews are concerned. The test figures in Table IV are for two large two and four-cycle engines of approximately the same horsepower ratings.

TABLE IV. FUEL CONSUMPTION OF TWO ENGINES ON TEST

Particulars	Pounds fuel per Br.hp.hr.	
Load in Per Cent of Rating	Two-Cycle Solid Injection	Four-Cycle Air Injection
100	.463	.398
75	.466	.401
50	.498	.438
25	.647	.567

Fuel oil of approximately the same heat content and gravity are represented in both tests. It should, however, be borne in mind that fuel performance alone is not the deciding factor.

Elusive Operating Costs of Small Power Plants

COLLECTING ESSENTIAL ITEMS FOR MAKING A MONTHLY REPORT OF POWER COSTS. BY G. H. KIMBALL

OFTEN the engineer of a small plant if asked what the power in his plant costs per kilowatt-hour, is at a loss to give an answer. He has spent most of his life in maintaining and adjusting machinery without much time to see how much it is costing his employers to run his plant.

Like everything else that happens in everyday life, the better understanding of the more important matters depends on the man. If the engineer does not expect to advance to larger plants he will be indifferent to a wider knowledge but many engineers are afflicted with a bump of curiosity so that in some way or another they begin to investigate the expense of operating their plant; thus in time they can often state just how much it is costing to operate it.

If a plant is producing nothing but electric current, all of the expenses can be gathered in one lump sum and this total, divided by the number of kilowatt-hours output, will give the rate per kilowatt-hour. In the case of a central station no matter what the capacity it should be comparatively simple to collect all of the expenses since everything that is done for the plant in any way should be charged to the cost of operation and thus the question is a matter of bookkeeping.

Taking industrial plants where steam is supplied for heating and process work, we have a more complicated problem and the writer recalls, when taking charge of a plant for a trade school, that it would be difficult to determine how much steam went for use in the experimental laboratory and if this could not be found, the cost per kilowatt-hour would be difficult to apportion. If a charge for steam must be made that is separate from that used for power, the water rate of the engines may be found by running a test and then from that as computed according to the load in kilowatts the remainder of the expense for fuel can be charged to process steam, and also the proper proportion of other expenses added.

A simple form of monthly cost report for operating expenses only may be arranged to tabulate: labor, superintendence, fuel, water, ash removal, repairs and supplies.

Under labor there would be included that of engineers, firemen, electricians and any other work that might be done by workmen not a part of the power house force. This item appears simple but the most difficult part is to take account of the work that is done by the general maintenance crew of the factory. A man will be called on to perform some small job and if great care is not taken, he will make no account of it and thus much work that should be charged to the power plant will never be accounted for.

If there is a plant engineer or superintendent of power some of his salary will have to be paid by the power plant, which will account for the next charge.

There is not much difficulty in keeping account of the fuel cost unless there is no method of weighing it in the boiler room. When scales are provided a check must be kept on the firemen to see that they stop to weigh every load as it is common practice to neglect this when they are in a hurry and estimate the weight. Some boiler rooms are not arranged so that it would be possible to weigh the fuel and then if the coal is delivered from a dealer the total of the weight slips for the month can be taken, which will be quite accurate for the yearly period. For a plant that keeps a considerable supply on hand, it is necessary to have some way of weighing it.

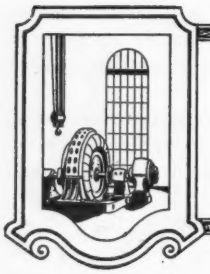
Water and ash removal do not present great difficulties and repairs would include those on any part of the plant equipment.

Supplies would include everything except fuel and water such as oils, waste, packing, tools, etc.

The total of the foregoing will give what is termed the expense of operation for the month. The output in kilowatt-hours can be taken from the switchboard meters, which should be tested at least once a year. From these figures the operating cost per kilowatt-hour can be computed and compared from month to month.

Though the preceding does not take account of fixed charges which are usually depreciation, taxes and insurance, yet if any comparison is desired between a rate offered by the central station and the rate per kilowatt-hour that the isolated plant is turning it out for, the fixed charges must be considered. Oftentimes equipment has been in use for a long enough period so that it can be written off the books. Another charge that might be confusing where the power house adjoins the main building is that of general repairs to the power house itself to which may be added the fixed costs. In some cases, if power is purchased, nearly all of the engine room space may be available for other purposes but the boiler room will often have to be retained and if it is necessary to install motor-generator sets and complicated switching apparatus, some room will have to be provided for that.

It is probable, however, if the operating charges are reasonably accurate, that the regular accounting department will be able to determine the fixed charges which will simply increase the rate a certain amount.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Relay Protection of Electric Generators

DESCRIBING THE PRINCIPAL SYSTEMS IN USE FOR PROTECTION AGAINST INTERNAL FAILURE OF A.C. GENERATOR WINDINGS

WHEN THOMAS EDISON was engaged in designing and building the first central station system, that of which Pearl St. station was the nucleus, he was confronted with the problem of protecting his generators

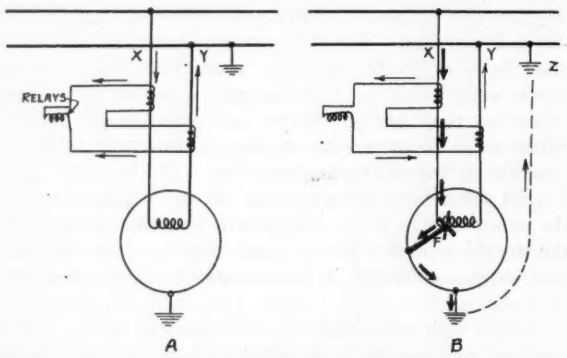


FIG. 1. DIAGRAMS SHOWING THE PRINCIPLE OF OPERATION OF THE SIMPLE DIFFERENTIAL SCHEME OF PROTECTION

from accidental overload due to short circuits or grounds. In May, 1880, he obtained a patent on the now well-known lead wire fuse, which when placed in the circuit melts on overload, thus disconnecting the generators. This was the first scheme of generator protection ever used and despite its simplicity it was effective.

The lead wire fuse or a modification of it is still in use but for generator protection it has been superseded by various other devices and schemes. As generators and systems increased in size, fuses gave way to automatic circuit breakers fitted with overload trips, from which the comprehensive scheme of relay protection in use today was finally evolved.

According to present day practice, it is not the custom to provide for automatically disconnecting the generator from the line in case of overload. Apparatus is provided only for disconnecting the generator in case of internal failure. Of course, excess current and temperature must be guarded against, but this is usually done by providing some visual or audible signal. With such an instrument in plain view or within hearing distance of the operator, conditions of load and temperature are always known and in the case of any abnormal condition, the generator can be manually disconnected from the line. Modern generators are designed to withstand successfully the effect of short circuits within themselves for a short time so as to permit the line relays to clear the faulty feeder.

If overload relays are provided on the generator, the time and current settings must be fairly high, with respect to the overload relay settings on the feeder circuits. That is, if a short circuit occurs on a feeder, the relays tripping the circuit breaker on that feeder must be set to act before and on current values lower than that for which the overload relays on the generator are set. If this were not done, the generator would be tripped off the line and the load dropped on feeders on which there was no trouble.

In all protective schemes, the fundamental problem is first to differentiate accurately between normal and

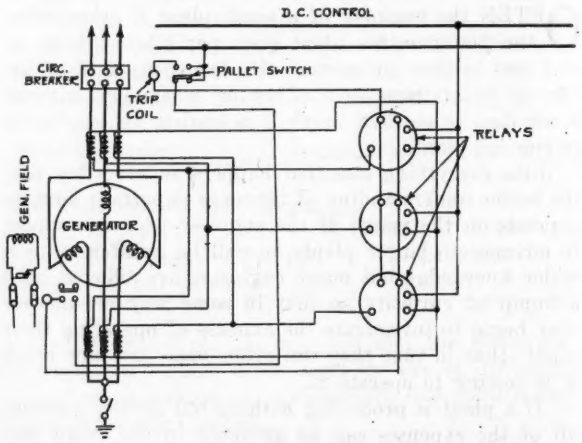


FIG. 2. DIFFERENTIAL PROTECTION OF THREE-PHASE GENERATOR

abnormal conditions; second, to distinguish positively, under abnormal conditions, between the faulty apparatus on line and the remainder of the system; and third, to remove the faulty apparatus from the system with the least possible disturbance.

Since it is the function of the feeder relays to disconnect faulty portions of the circuit from the rest of the system, the only condition which makes it necessary to disconnect the generator from the bus is internal failure in the generator itself.

In furnishing protection against internal failure, two kinds of failure are usually considered, failure of the field winding or failure of the armature or stator wind-

ing. Except in the case of very large machines protection against field failure is not usually considered justifiable because of the infrequency of its occurrence. The field circuit operates at a relatively low voltage and the danger of failure is far less than it is in the armature circuit.

Armature faults usually start as grounds to the generator frame. If the neutral is not grounded a fault of this sort will not unbalance the phase current and it is therefore rather difficult to locate until it has developed into a phase-to-phase short circuit, which it usually does. From the viewpoint of protection it is advisable to have the neutral grounded.

Differential System of Protection

It is highly desirable, however, in case of a ground to disconnect the generator from the line before it develops into a phase-to-phase short, since by doing so much greater damage to the machine can be avoided. This is usually accomplished by the use of differentially connected over-current relays or biased current differential relays, although there are several other schemes. Differential schemes include all schemes in which currents, however large, flowing in their proper paths are balanced against each other so as to have no effect on the protective relays, whereas any current diverted from its proper path as the result of an internal fault operates the relays.

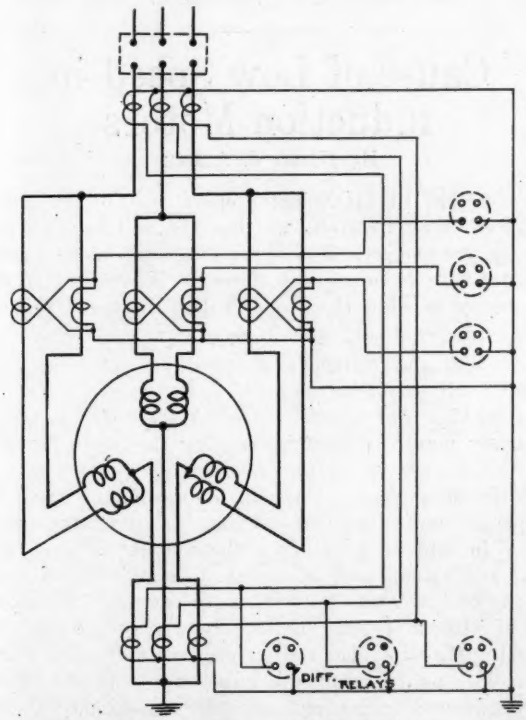


FIG. 3. COMBINATION OF SPLIT CONDUCTOR AND DIFFERENTIAL SCHEMES ON A 2-CONDUCTOR, 3-PHASE GENERATOR

Figure 1 shows the principle of the simple differential scheme a little more clearly. Each of the two leads of the single phase generator, it will be noted, is provided with a current transformer, the secondaries of which are connected so that the voltages oppose each other. Since, under normal conditions, the current in one of the generator leads is exactly the same as that in the other, the voltages in the transformer secondaries are exactly balanced against each other and no current flows through the relay coil. If, however, a ground occurs at F as shown in Fig. 1B, some of the current in lead X, instead of going out by way of lead Y will pass through the fault to ground and return to the bus at the ground connection Z. The e.m.f.'s induced in the secondaries of the current transformers in this case will no longer be equal, causing a current to circulate through the transformers and the relay coil as shown. This immediately trips the main circuit breaker removing the generator from the bus.

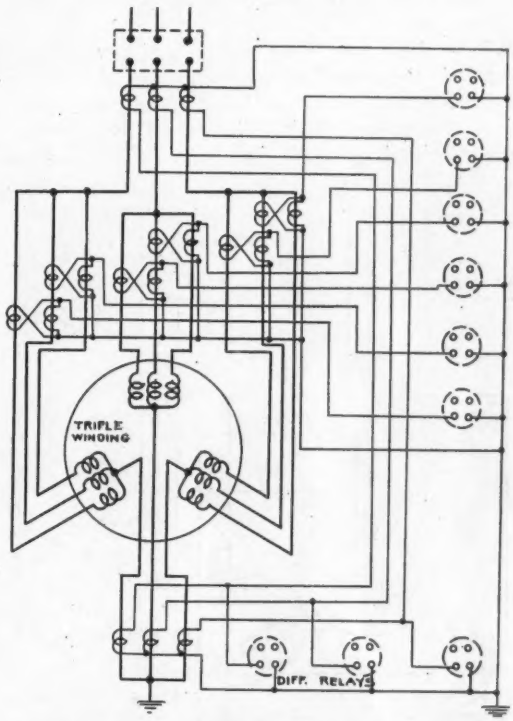


FIG. 4. COMBINATION OF SPLIT CONDUCTOR AND DIFFERENTIAL SCHEME ON A 3-CONDUCTOR, 3-PHASE GENERATOR

This is the most common form of generator protection. It is simple and highly effective under most conditions of trouble. It has some limitations such as failure to protect against short circuited turns and open circuits, and unless high ground resistance is used it does not operate on a ground until a short circuit has developed.

In applying this scheme to the protection of three-phase generators, both ends of each winding are brought out of the machine as shown in Fig. 2, and current transformers installed on each end. A relay operates to close its contacts whenever the current becomes unbalanced in two corresponding current transformers, which in turn trips the circuit breakers and disconnects the machine from the line.

The diagram shown in Fig. 2 illustrates the application of this system to a single winding machine. Large generators, however, are usually provided with parallel windings, that is, each phase winding is composed of two or more separate conductors in parallel. This arrangement has made it possible to protect against all

types of internal failures, including open circuit and short circuited turns, by the use of the so-called split conductor protective scheme and the differential system. Such an arrangement is illustrated in Fig. 3.

In this system, as will be obvious from a study of the diagram, the currents in the two halves of the winding are balanced against each other instead of having the current in one end of the winding balanced against that in the other end. Differential protection is secured in the same manner as previously described, separate current transformers and relays being provided for this purpose.

Where there are three conductors per phase, the principle is the same but the connection of the current transformers and relays on the balanced conductor protective scheme is slightly different. This difference is shown in Fig. 4.

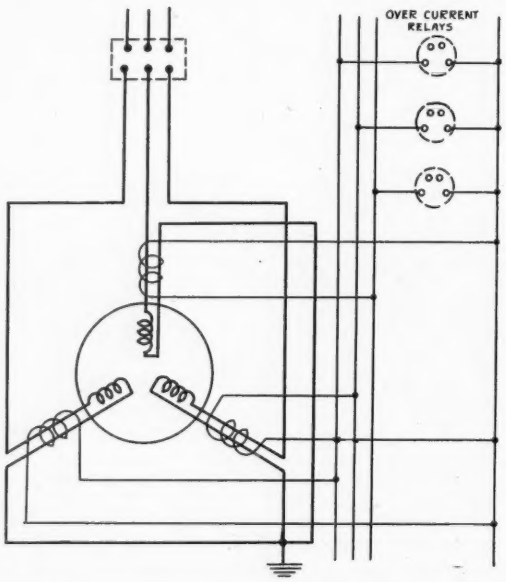


FIG. 5. THE SELF-BALANCED SYSTEM OF PROTECTION

The advantages of the split conductor method of protection make its use well worth while. It protects against all internal faults, including phase to phase short circuits, grounds, short circuited turns, and open circuits. The sensitive settings that are possible with this arrangement detect an open circuit or a short circuited turn immediately when it occurs. To offset these advantages, the scheme is more complicated and has a higher first cost and maintenance than the simple differential scheme.

The Self-Balanced Scheme

One other system of generator protection should be described. This is the self-balanced scheme, a simplification of the ordinary differential system. As shown in Fig. 5 this scheme is essentially the same in principle as the simple differential scheme, but only one set of current transformers is used. The two ends of the same phase winding are carried through the same current transformers. Since under normal conditions, the current in one of these leads will exactly balance that in the other lead no current will be induced in the secondary winding of the transformer. If a fault occurs in the winding, the current values in the two leads passing through the transformers will no longer be the same and a current will be induced in the secondary proportional to the difference between the current values in the two leads.

The advantage of this system is that it is not affected by the normal unbalance due to two transformers, having dissimilar characteristics which makes possible a very sensitive relay setting. It protects against faults in the winding, but not in the leads from the generator to the bus.

Its disadvantages are that it needs special current transformers and there is danger in carrying two leads having large potential difference in such close proximity through the transformer.

This brief discussion of methods of generator protection does not cover all schemes of relay protection. Only those most commonly used have been discussed and these only from a general point of view. The particular scheme to be used in any case depends upon the type and size of machine, the character of the load and upon the importance of the machine to the system.

Cause of Low Speed in Induction Motors

By Harry J. Achee

IF AN INDUCTION motor operates below its rated speed, first ascertain whether the voltage and frequency are correct. Too low voltage causes decreased torque, with a consequent decrease in speed. If the frequency is below the proper value, the speed will, of course, decrease correspondingly.

If both the voltage and speed are all right, the motor itself would be examined next. Look over windings for shorts or open circuits. A short circuit would probably manifest itself by causing the motor to take excessive current; also by overheating the insulation, etc. In three-phase motors one of the phases might be inoperative, due to open circuits. In the rotor, especially in squirrel cage types, there might be open circuits cutting out part of the winding and reducing the torque or there may be some loose connections making the effective resistance of the rotor greater, thereby increasing the slip. The writer has known of cases where the solder used in connecting the bars to the end ring, or conductors in squirrel cage rotors had melted and the poor connection resulting had raised the rotor resistance so as to render the rotor unfit for service until it was repaired.

If the windings are found in good condition, ascertain what load the motor is carrying; overloads will, of course, cause the rotor to slow down.

If the cause of the trouble still remains unrevealed, it will doubtless prove to be of a mechanical nature. The bearings may be too tight or the shaft may be sprung or bent, thus causing excessive bearing friction.

Should these points fail to disclose the annoyance, the air gap of the motor should be checked. If the depth of the air gap is too great, there will be an abnormal leakage of the flux and a corresponding reduction of speed and torque. The bearings might be worn or the armature incorrectly lined up, causing too large

a gap on one side and too small a gap on the other side, or even allowing the armature to rub against the field punchings.

An interesting case of this nature came to the writer's notice some time ago, where a two-horsepower induction motor, installed in a small machine shop, was belted to an emery wheel below. The tension of the belt caused the bearing to wear into an elliptical shape and allowed the rotor to come down and rub against the field laminations. The motor was thus forced to overcome this friction in addition to operating the emery wheel and as a result the fuses were blown quite often, both when starting and whenever an extra amount of pressure was exerted on the tool that was being ground. The fuse renewal became necessary entirely too often to suit the proprietor; so the motor was taken down and sent to the local electrician.

The wear on the lining of the bearing was, of course, on the lower side, when the motor was suspended from the ceiling, in an inverted position; but when placed on the floor this worn part was the top of the bearing and could not affect the rotor position. On the floor the motor was apparently in perfect condition, and after the electrician ran it free for a few minutes, he returned it to the machine shop with a set of larger fuses and his bill for repairs.

Upon putting the motor back into place, it was tried several times and found to operate satisfactorily; but after the bearing had worn a little deeper, even these larger fuses had to be replaced. The machinist now lost patience and after a personal examination, decided that the rotor was too large. Acting upon the impulse, he put the rotor in a lathe and took off a cut of several hundredths of an inch, whereas the original air gap had been only an eighteen thousandth. The rotor was then assembled and once more returned to its place on the ceiling. Now no fuses were blown and the motor apparently ran all right, but seemed suddenly to develop a disposition towards extreme laziness; whenever any grinding was attempted, any ordinary pressure exerted on the wheel would stop the motor altogether. Needless to say, the trouble was now due to the reduced turning effort caused by the abnormal magnetic leakage due to the greatly increased air gap.

Finally the matter was adjusted by a new rotor and another set of bearings.

Operation of Brown Boveri Voltage Regulator*

USED EXTENSIVELY IN EUROPE THIS REGULATOR POSSESSES MANY FEATURES OF INTEREST TO AMERICAN ENGINEERS. BY OTTO NAEF†

IN THE BROWN BOVERI automatic voltage regulator, the controlling element which registers the voltage fluctuations operates a field rheostat directly without the aid of auxiliary power. To accomplish this it was necessary to design 1. A sensitive and powerful control device. 2. A field rheostat with a minimum of friction and inertia in its moving parts. 3. A system of balanced moving parts free from reaction in every position. 4. An effective and simple anti-vibrating device.

Figure 1 shows the principles of this regulator. On the left are shown the stationary contacts of the field rheostat with the resistance elements connected to them. The black circle represents the drum of a split phase induction motor which is the control device and furnishes the power for moving the sectors. Attached to the spindle of the drum are two leaf springs carrying jewel cups which press the sectors against the stationary contacts. There are two sectors in the small regulator and four in the large regulator. The drum is free to move through an angle of 60 deg. and is counterbalanced by a system of springs. As the drum turns under the influence of slight variations in voltage, the needle points of the sectors are carried over the arc of a corresponding circle and the sectors roll in the groove of the stationary contacts putting in or cutting out resistance in the shunt field circuit of the exciter. This design of the field rheostat entirely eliminates sliding friction and replaces it by rolling friction which is so small that it can almost be neglected. All moving parts are made of aluminum. The inertia therefore is small and as only small displacements are required to cover the whole regulating range, the moving system responds very quickly to changes in voltage. The figure shows that the reaction from both sectors is perfectly balanced and does not exercise a torque on the spindle.

Figure 2 shows the electrical connections of the control device. The resistance U is placed in series with the split phase winding to make the torque independent from slight variations in frequency and temperature. The current influences the voltage impressed on the coils through an adjustable portion of the resistance U, or through a small auxiliary current transformer (not shown).

Figure 3 shows the complete mechanism. All parts are self-contained in one casing, the resistance wire being directly secured to the contacts by screws; "f" is the main spring and "n" the auxiliary spring, the combination of which produces constant torque over the full range. The torque of the springs is counterbalanced by the electrical torque of the drum "c." By weakening the auxiliary spring the regulator can be given a static or drooping characteristic. The device in the center prevents vibrating, and is called the recall device. It consists of an aluminum disk (o) rotating between two permanent magnets (m). The disk is geared to the rack of an aluminum sector (p) which can turn concentrically with the rotor spindle and is fastened to the aluminum drum (c) by means of a flexible spiral spring (q), acting as a recall spring.

The cycle of operation is explained on Fig. 4, which shows diagrammatically the mechanism and electrical connections of the regulator. The pointer indicates the position of the sectors, and is therefore a measure for the exciting current and the load. In position zero the whole rheostat in the regulator is short-circuited, corresponding to maximum excitation, and in position 4, all resistance is in, corresponding to minimum excitation. The amount of resistance is usually so chosen that the range from no load to full load of the generator

*Abstract of a paper delivered before the Electrical Apparatus Committee of the N. E. L. A.

†American Brown Boveri Electric Corp.

lies between positions 3 or 3.5 and 1. If the regulator is at rest, the electrical torque exactly balances the spring torque. As the latter is constant between position 0 and 4, any small increase or decrease in the electrical torque immediately tends to turn the rotor to the extreme left or right, where its further movement is checked by a stop. It can easily be seen that, save for the recall device, the smallest variation in voltage would send the pointer continuously surging from one extreme position to the other extreme position. The regulator would continuously vibrate, and the exciter current would fluctuate around a mean value. The recall spring, however, temporarily exerts an additional torque, which causes the momentary displacement of the sectors to be proportionate to the change in the electrical torque. If the electrical torque, for instance, increases because of a small increase in voltage, due to a drop in load, the sectors are displaced to the left till the mechanical torque, now increased by the torque of the recall spring (q) again equals the electrical torque. The resistance inserted in the field by the displacement of the sectors is much in excess of what would be necessary to adjust the excitation to the new load condition. In this way the inertia of the magnetic fields is rapidly overcome and the voltage falls fast towards normal; however, before normal voltage is fully attained the sectors already start to reverse because of the small torque still exerted by the recall spring, the tension on which has been reduced through the following up of the aluminum disk. The rapid descent of the voltage is therefore broken and the sectors come to rest in a position corresponding to the correct excitation. The recall spring is made weak and heavy load fluctuations therefore cause the pointer and sectors to swing rapidly to one of the end positions, putting in or cutting out all resistance. In this case a few rapidly damped oscillations follow until the sectors come to rest in their new position of equilibrium. Regulation is stable over the whole range of the regulator.

Speed of regulation depends on the time constants of exciter and generator, which should be made as low as possible. This regulator has no different requirements in this respect from any other regulator. There are three elements in the regulator which can be adjusted to suit particular conditions. These are the amount and grading of the resistance, the stiffness of the recall spring and the damping. The latter two depend chiefly on the combined time constant of generator and exciter, which are in a large measure determined by output and speed. Adjustments are made at the factory accordingly, which need rarely be changed at the first setting to work. The amount and grading of the resistance is determined by the saturation curve of the exciter if loaded with the field of the generator. Figure 6 shows a typical curve.

It is necessary to know at least the points correspond-

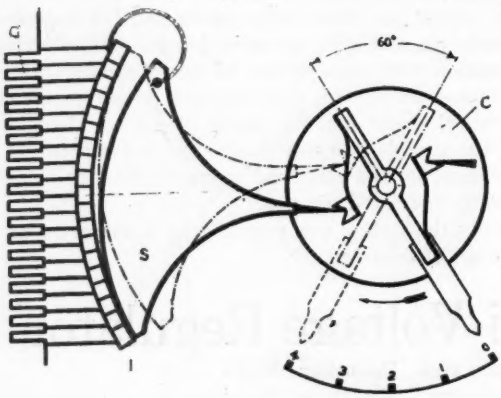


FIG. 1

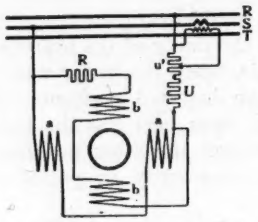


FIG. 2

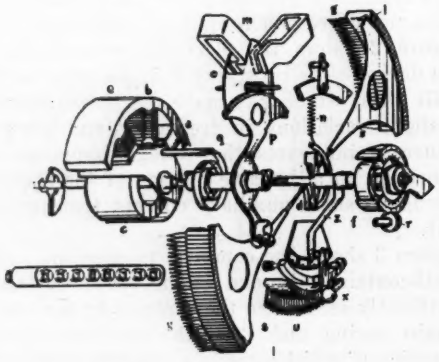


FIG. 3

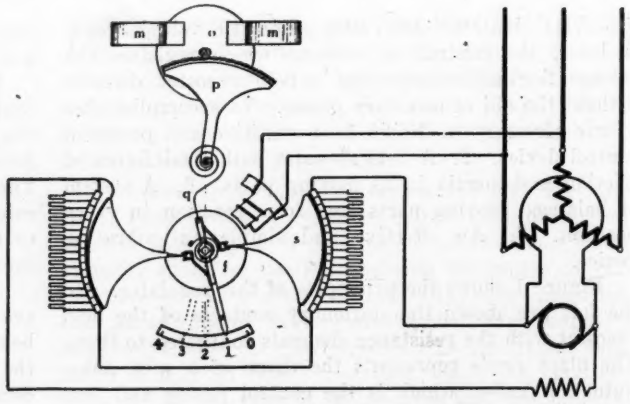


FIG. 4

FIG. 1. ROTOR, SECTOR AND CONTACT SEGMENT OF A CURRENT LIMITING REGULATOR. FIG. 2. DIAGRAM OF CONNECTIONS OF THE MOTIVE SYSTEM OF THE QUICK ACTING REGULATOR FOR 3-PHASE CURRENT. FIG. 3. MOTIVE SYSTEM AND REGULATING MECHANISM OF THE REGULATOR. FIG. 4. DIAGRAM ILLUSTRATING REGULATING PROCESS

ing to no load and full load of the generator and the resistance of the shunt field winding. From these the amount of resistance variation can be calculated, which is necessary to take the generator from no load to full load. An addition is made to provide for over-regulation and to compensate for possible speed variations. It is always of advantage, however, if the whole saturation curve is known. Resistance sets of different ohmic capacity and grading are kept at the factory, from which the suitable one is selected.

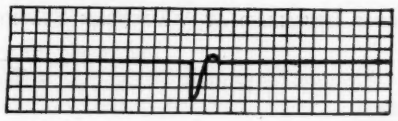


FIG. 5. REGULATION CURVE SHOWING THE VARIATION OF THE ALTERNATOR VOLTAGE

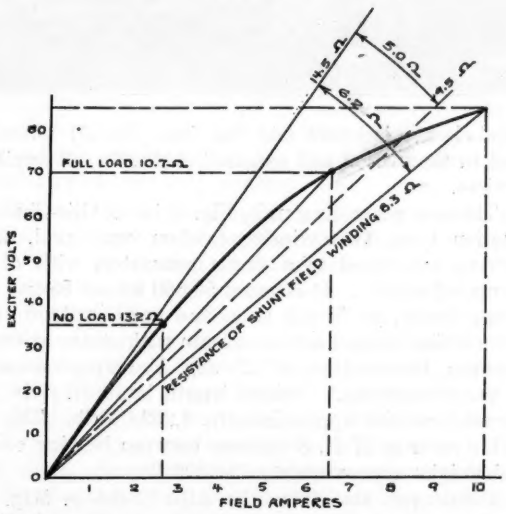


FIG. 6. SATURATION CURVE OF A SHUNT WOUND EXCITER

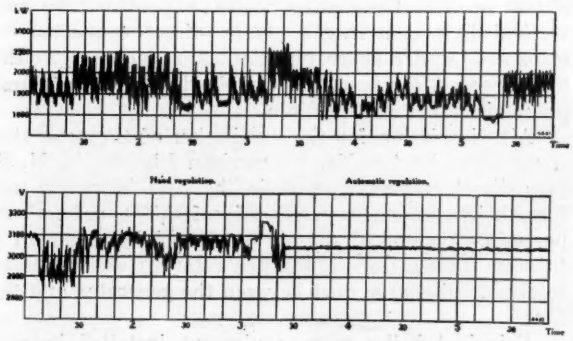


FIG. 7. LOAD AND VOLTAGE WITH AND WITHOUT VOLTAGE REGULATION

It is possible to use one regulator for the control of more than one exciter, but this rarely is done and never recommended. The recommended practice is to use for each generator its own regulator and exciter, either direct connected for high and medium speed, or motor driven in case of very low speed. Regulation is done exclusively in the shunt field of the exciter, and a generator field rheostat is omitted as wasteful and unnecessary. Some exciters are unstable at very low loads so that regulation by hand becomes almost impossible. Automatic regulation in most of these cases is still satisfactory, because of the always present hysteresis.

Figure 7 shows a typical voltage chart taken from a power station bus with and without automatic regulation.

New Way of Building Large Synchronous Condensers

THREE SYNCHRONOUS condensers larger than any now in service are to be used to regulate the voltage of the transmission lines which carry power from the Big Creek hydro-electric development into Los Angeles. The machines, built by the General Electric Co. for the Southern California Edison Co., are each rated at 50,000 kv.a. and will operate at 13,200 v., 50 cycles and 600 r.p.m. Two are to be installed in the new Lighthipe substation and the other in the Eagle Rock substation.

In the construction of these 50,000-kv.a. condensers the General Electric Co. has used a minimum of castings and a maximum of fabricated steel plates. The bearing pedestals and the base are the only large castings; most of the other mechanical parts are of rolled steel plates. In this way strength was secured without undue weight and without the expense and delay of making large patterns. The total weight of each condenser with its exciter is 375,000 lb., and the overall dimensions are 26½ ft. long, 16 ft. wide, and 12 ft. high above the bottom of the base.

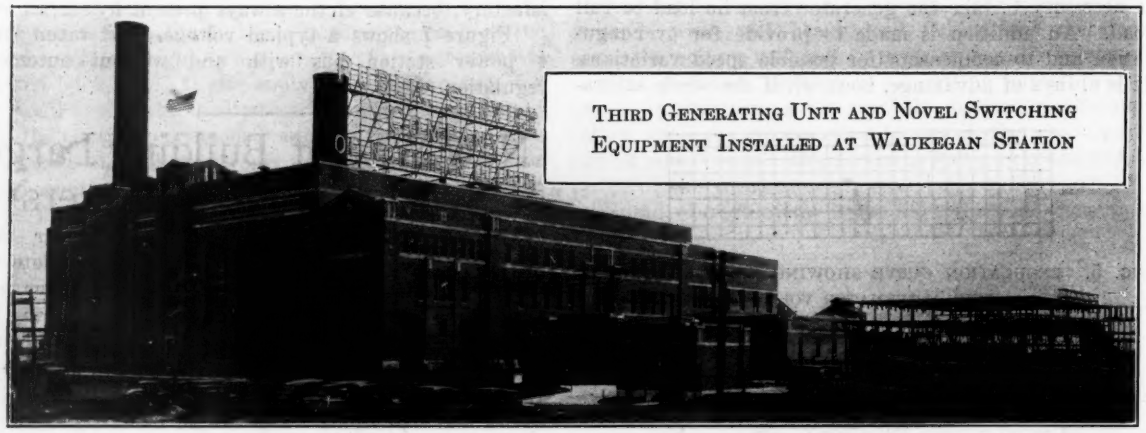
The stator frame is of steel plates, electrically welded into a rigid structure and split horizontally to facilitate shipment. The main body is of six annular rings cut from steel plates, with triangular projections to which the feet are welded. A curved plate is welded to the outside periphery to form the outside cylindrical surface. To the inside periphery are welded rectangular steel bars, slotted to receive the dovetail keys carrying the stator punchings. This type of frame, which has been used for many horizontal and vertical shaft machines, has light weight and great strength, is neat in appearance and, being smooth inside, offers little obstruction to the flow of air. The field spider consists of four sections shrunk onto a heavy forged steel shaft. Each section is made of laminated steel plates, with the dovetail slots, the spring pockets and the hole for the shaft made in a punch press. At normal speed each of the ten poles exerts a pull on the rotor of 3,000,000 lb. due to centrifugal force.

Bearings are of the ball seat, self-alining, ring oiled type, babbit-lined. Each bearing is provided with a dial-type indicating thermometer, water-cooling coils, and pipes for oil pressure starting. They are carried by heavy cast iron pedestals that contain their own oil reservoirs.

The direct-connected exciter is rated at 165 kw., 250 v. The magnet frame is of hot-rolled steel; the only castings in it are the armature spider and the support for the brush rigging.

Each of these three synchronous condensers is to be equipped with General Electric surface air coolers, located in the pit beneath the machine.

50,000 Kw. Added to Chicago Pool of Power



THIRD GENERATING UNIT AND NOVEL SWITCHING EQUIPMENT INSTALLED AT WAUKEGAN STATION

INSTALLATION of the third generating unit, a steam turbo-generator of 50,000 kw. capacity, recently put into service at the power station of the Waukegan Generating Co. at Waukegan, Ill., constitutes an important and notable addition to the sources of electrical power distributed in the territory of Metropolitan Chicago.

The Waukegan Generating Co. is a subsidiary of the Public Service Co. of Northern Illinois, which serves some 286 communities in an area containing over 6000 sq. mi. surrounding Chicago and interchanges power with the Commonwealth Edison Co. at the center and with other utility companies at the borders of the territory it serves.

Located approximately midway between Chicago and Milwaukee, with which cities connections are made, the Waukegan power station is built on the shore of Lake Michigan, with an unlimited supply of condensing water available and but a short distance from the coal fields of central and southern Illinois, thus being well situated for the steam generation of electrical power on an unusually economical basis.

Building construction has been carried out on a two-unit basis, the building for generating units Nos. 1 and 2 being completed in the year 1923, at which time the first unit was installed, the second unit being added 2 yr. later.

These generating units are rated 25,000 and 35,000 kw. respectively. Steam is furnished to each of them from three boilers at 400 lb. pressure, the two sets of boilers being interconnected. Three-phase, 60-cycle current is generated at 12,000 v. and distributed at 12, 33 and 132 kv. Electric driven auxiliaries for these units are supplied at 480 v., obtained through step-down transformers.

Following the general lines of the various installations, the new installation differs from them in many important particulars and presents a number of interesting developments, some of which are new to the practice of power plant construction in the United States. Among these differences and developments may be mentioned the use of steam at 600 lb. pressure, the use of preheated air at the furnaces, the closed system of ventilation of the generator with air circulation produced by independent motor-driven fans, the use of 2300-v., motor-driven auxiliaries starting on full voltage, metal-clad switchgear and bus bars for all potentials used in the station and armored cables for all auxiliary services.

The new generating unit, Fig. 1, is an Allis-Chalmers reaction type, two-cylinder, tandem compound, steam turbine, connected to a single generator, with direct-connected exciter. It is rated 50,000 kw. at 85 per cent power factor, or 58,825 kv.a. and runs at 1800 r.p.m. The turbine is designed to operate with steam at 600 lb. pressure, temperature of 725 deg. F. and a vacuum of 29 in. of mercury. Overall length is 79 ft. 4 in. and the total weight, approximately, 1,233,000 lb. The generator rotor is 27 ft. 8 in. long between bearing centers and weighs approximately 146,500 lb.

Condenser, also from the Allis-Chalmers Mfg. Co., is of the surface type and contains 10,900 1-in. brass tubes, 20 ft. long, giving a total condensing surface of 57,000 sq. ft. Circulating water is provided by two vertical-shaft centrifugal pumps direct connected to two-speed, squirrel-cage type induction motors. At the high speed, 250 r.p.m., the combined capacity of these pumps is 70,000 gal. per min.

Air circulation for the ventilation of the generator is produced by two No. 8 American Blower Co. H. S. fans direct connected to Allis-Chalmers induction motors, their combined capacity being 160,000 cu. ft. of air per min. Cooling of the air is effected by means of a Griscom-Russell Co.'s U-Fin generator air cooler located in the air discharge duct between the generator and the fans.

Principal boiler room equipment installed in connection with the new unit consists of four Babcock and Wilcox boilers equipped with B. & W. chain grate stokers, economizers, forced and induced draft fan equipments—the forced draft fan equipment forming a part of the Ljungstrom air preheating system—Elliott Co. feed-water heaters and deaerator. Each boiler, with a total heating surface of 14,369 sq. ft., and an effective grate surface of approximately 467 sq. ft. is designed to evaporate, as a maximum, 200,000 lb. of water an hour from the temperature of the feed to a steam pressure of 635 lb.

It has two motor-driven, forced draft fans, delivering the preheated air at 350 deg. F. and one American Blower Co. induced draft fan, driven by two Fairbanks,

Morse & Co. variable speed motors, one for 230 to 490 r.p.m., the other for 490 to 700 r.p.m. All fan motors are of slip-ring, wound-rotor type.

For the chain grate stokers, operation of small capacity motors over an extremely wide speed range was solved by the wound-rotor, brush-shifting, adjustable-speed motor recently developed by the General Electric Co. and this type has been applied to all stokers in the station. These motors rate 10 hp. at 1760 r.p.m. and 2½ hp. at 440 r.p.m., operating satisfactorily at all speeds within the range.

Two motor-driven Worthington boiler feed pumps are direct connected to 600-hp., 1800-r.p.m. Fairbanks, Morse & Co. squirrel cage motors, started through reactors which are automatically short-circuited through appropriate switches when the starting current has fallen to a predetermined value.

Auxiliary motor switch control system has been developed to reduce the possibility of human error in the operation of the equipment to a minimum, noticeably as in the above case, also in the provision made to transfer automatically the load between the two motors on each induced fan and to change the speeds of the two-speed, circulating-water-pump motors.

Throughout the station alternating current is used exclusively for the motor-driven auxiliary equipment. In the new installation all the motors driving auxiliary equipment rated 50 hp. and above are 2300-v., the smaller ones 440-v. Except for the stokers and the forced and induced draft fans, all motors are of the squirrel cage type. With the exception of those for the boiler feed pumps all motors are started at full voltage. The largest of these are the 275-hp., 250-r.p.m. circulating water pump motors and the high-speed, 150-hp., 1760-r.p.m. generator-air-fan motors. Service for the auxiliary motor equipment is obtained from step-down transformers.

Throughout the station are to be observed the armored cables, furnished by the Standard Underground Cable Co. and the Safety Cable Co., used for the distribution of the auxiliary power and control services, lighting feeders, etc. Those are varnished-cambric and 30 per cent Hevea-rubber-insulated, braided and lead covered, according to the services and locations, and closely wrapped with two layers of steel tape. They range in size from three-conductor, 600,000-circ. mil to two-conductor control wires. In general, the armored cables lie in troughs, this method eliminating many of the otherwise necessary conduits, the disposition and installation of which, in the modern large generating station, have become a serious problem, due to the large sizes, the numbers involved and the difficulties encountered in adapting them to the building construction, the mechanical equipment and piping layout.

But it is when we enter the switch-house that we find the greatest departure from the general standards of American generating station development and construction. Additions in the operating room follow closely the scheme established by the preceding units but elsewhere the most unusual is encountered.

Of the three-story switch-house, in the main or upper story is the main or 12-kv. switching structure; in the story below are the main bus reactors and the auxiliary transformer circuit reactors; in the lower story are the 2400 and 480-v. auxiliary switching structures; while in the basement of the boiler house is a switch room containing the switch-gear, controllers and grid resistances for the draft-fan motors. Switch-gear in this room is virtually an extension of the 2400-v. switch structure in the lower story of the switch house.

It is not, however, in the arrangement, but in the nature of the switch-gear, that we notice the unusual. The main or 12-kv. switching structure, Fig. 3, is unique in American practice. Seven panels or units of Allis-Chalmers Reyrolle, Type M metal-clad switch-gear with double-deck, twin, main and reserve metal-clad bus bars constitute the present installation. This is the first use of this type of switch-gear in a generating station in the United States and the main switches are the largest of their kind in the world.

Switch panels or units are arranged in two parallel rows with the bus-bars in parallel rows above but be-

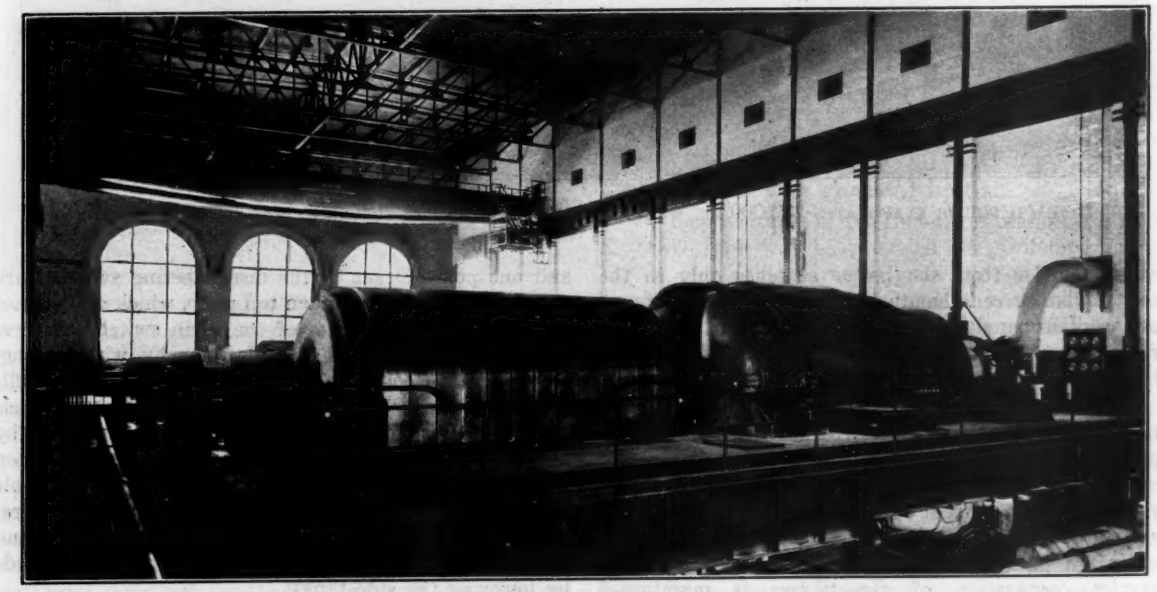


FIG. 1. 50,000 KW. GENERATED AT 600 LB., 725 DEG. AND 29 IN.

tween the switch rows. Though a reserve bus bar is provided, largely as a means of connection between the switch structures previously installed and those it is anticipated to install in the future, the switch-gear provides but one switch on each circuit. Excepting, of course, the bus-sectionalizing switches, the switches are arranged for connection to either bus bar by means of selector disconnecting switches.

Switch panels for the main services are rated at 3000 amp. (30 deg. C. rise) 12,000 v., with an interrupting capacity of 1,500,000 kv.a. Switch panels for the auxiliary transformer circuits, rated at 600 amp. adjacent phases are separated by portions of the metal enclosing structure, which is grounded.

In general, a switch panel may be described as consisting of three main single-phase switch tanks, resting on a common bed plate, surmounted by a massive common top plate, with disconnecting switch tanks on both sides of the main tanks and with the necessary trunks for the connections to the bus bars on one side and to the outgoing or incoming cables on the other side. A fixed portion of the panel is supported by brackets, attached to posts mounted upon the bedplate. The main and arcing contacts and mechanism of the three phases

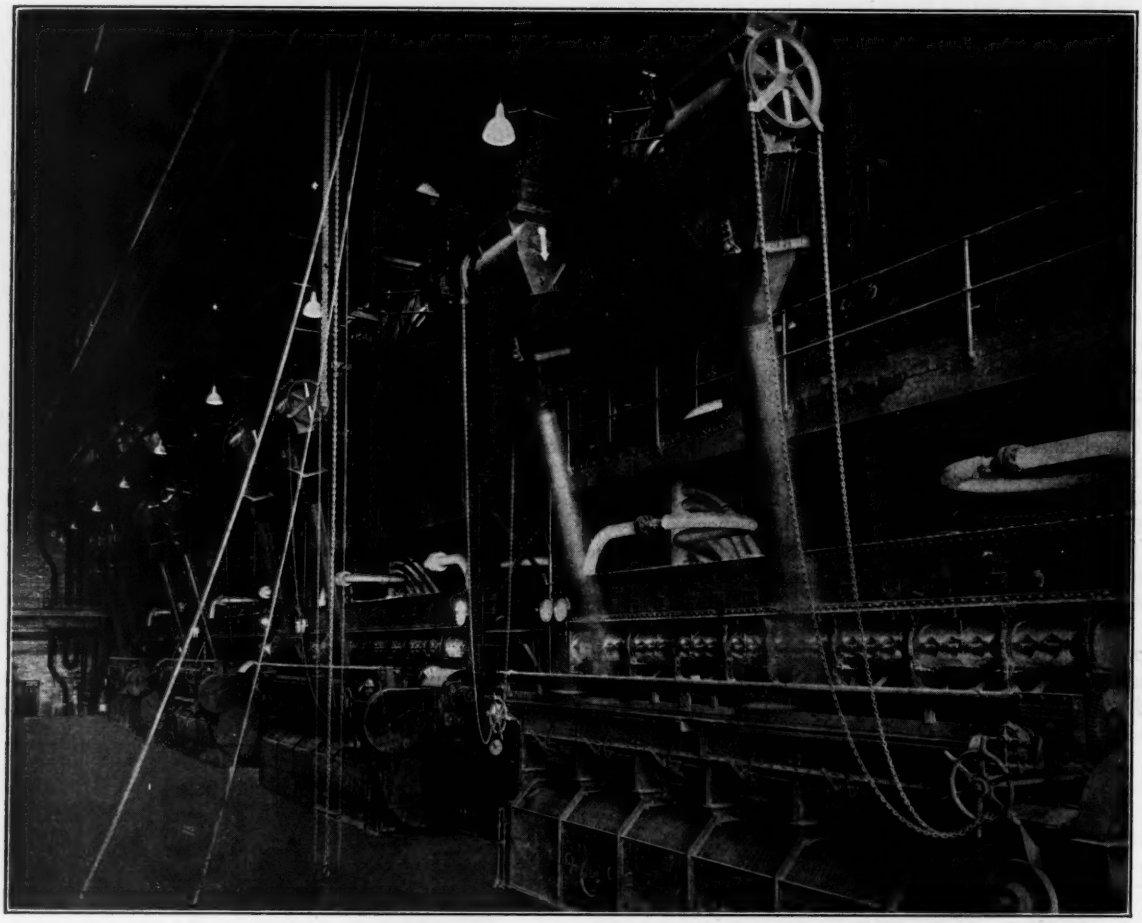


FIG. 2. EACH BOILER EVAPORATES 200,000 LB. WATER AN HOUR AT 635 LB., SERVED BY 467-SQ. FT. CHAIN GRATES

capacity, differ from the larger switches only in the sizes of the current conductors and contact surfaces. Each switch panel with its complement of bus bars weighs about 24 t. and occupies a space 12 by 14 ft. by 14 ft. high.

Each switch panel is a complete unit from the bus bars to the connecting cables, with all live parts metal-clad. The bus bar disconnecting switches, main and arcing contacts, cable disconnecting and grounding switches and the current and potential transformers are immersed in oil. Bus bars and the fixed conductors in the switch panel are buried in insulating compound. Complete separation of the phases is maintained throughout the whole equipment while, at all points, and one pole of each of the disconnecting switches are supported from the common top plate, which also carries the operating mechanism of the main switch. Inspection of the contacts is provided for by withdrawing, vertically, the complete top plate with its attached fittings, the removable portion of the large switch panels weighing approximately 7½ t. Removal is effected by means of a Whiting Corp. travelling crane. A skeleton panel structure is provided upon which the removable portion may be placed for inspection and test operations, while inspection of the disconnecting switches and of the current and potential transformers may be made by lowering the side tanks.

Each switch panel is mechanically interlocked so that

all the operations of the disconnecting and grounding switches can be made only in established sequence and so that no live parts may be exposed at any time. The group of switch panels are also electrically interlocked so that no bus-bar connections at the selector disconnecting switches may be exposed while the corresponding bus-bar is live. Also switch panels are interlocked,

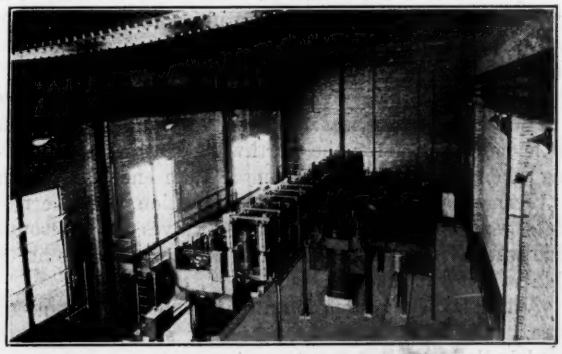


FIG. 3. MAIN 12-KV. SWITCH STRUCTURE IS IN PANEL FORM. BUS-BARS ARE ENCLOSED AND BETWEEN THE TWO SWITCH BANKS

with the traveling crane control so that hoisting operations can be performed only when the crane hook is immediately over the particular panel involved and then only provided the main switch and all the necessary disconnecting switches are open.

The 2400 and 480-v. auxiliary switching structures, previously referred to, are almost as unusual as the

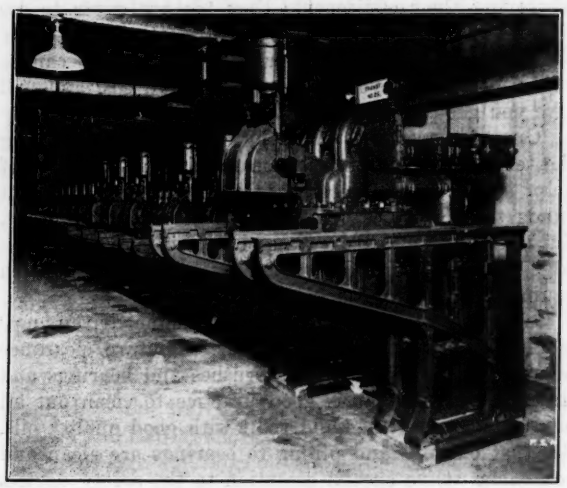


FIG. 4. AUXILIARY SWITCHING EQUIPMENT IS OF HORIZONTAL DRAW-OUT PANEL TYPE. PANELS OF THE A. B. AND C. TYPES

main switching structure, being made up of switch panels of substantially similar characteristics but of different types, Figs. 4 and 5. These structures are made up of switch panels or units of the A, B, C, and E types. Panels of these types are adaptable to the great variety of conditions incident to distribution at the lower potentials and where the interrupting capacities required are limited. These switch panels are of the horizontal draw-out type with air break, plug-and-receptacle disconnecting switches. When the switches are drawn out, automatically-operated doors effectively prevent access to the bus-bar disconnecting switch receptacles. Access to the main contacts is obtained by lowering the switch tanks.

In the selection of the switch-gear for this installation, especially the main switch-gear, paramount consideration was given to the following features: 1, the highest possible degree of safety; 2, large interrupting capacity with complete separation of the phases; 3, elimination of possible human error in the sequence of switching operation; 4, reliability. All these features are found to a high degree in the types chosen.

While the cost of such equipment is, of course, higher than that of comparable equipment of the usual type, a considerable saving is effected in other phases of the

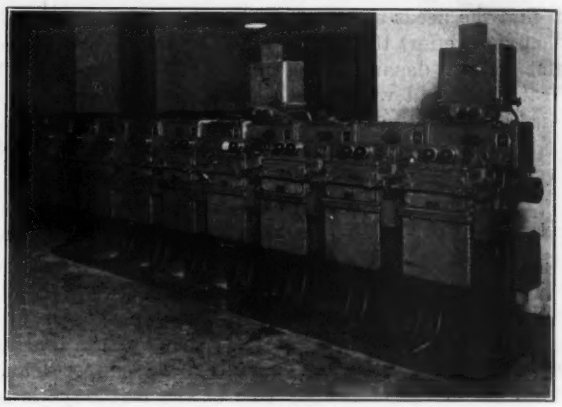


FIG. 5. TYPE E PANELS ARE FOR SMALLER CAPACITIES

installation by the elimination of switch cells, simplification of building requirements and simplicity of installation. The safety feature is, of course, difficult to evaluate.

Construction is now under way on a large outdoor transformer and switching yard for the 132-kv. transmission lines originating at this point. The present plans provide for ten lines, the immediate development providing for three lines with the necessary main and transfer busses and transfer bus tie line.

Four 20,000-kv.a. Westinghouse water-cooled transformers with facilities for changing voltage taps under load are being installed. Three of these will be connected to form a 60,000-kv.a. bank, 12,000 v. delta to 132,000 v. star, with grounded neutral.

Outdoor switches of the General Electric Co.'s F. H. K. O.-39 type will be provided for switching on the 132-kv. side of the transformers and on the outgoing lines and transfer bus tie. Potential and current transformers on the high-tension side will provide for synchronizing, differential and overload protection and for metering.

Acknowledgment

BY OVERSIGHT, credit was omitted from the article on the 3300-lb. Benson boiler in the July 1 issue of Power Plant Engineering for data and illustrations used. These were from an article by Wilhelm Abendroth, Dipl. Ing. of Siemens-Schuckert Werke in Zeitschrift des Vereines Deutscher Ingenieure, of Berlin.

Heating Systems Need Summer Overhauling

PIPING, THERMOSTATIC CONTROL, FANS AND RECORDING INSTRUMENTS TO BE PUT IN SHAPE. BY JOHN J. NOVOTNY*

DURING the summer months when the heating system is shut down, the engineer should be giving thought to removing the causes of complaints made during the past heating season as to too much heat or not enough heat. Merely wishing that this could or should be done is a waste of energy and brings no results. You must have specific plans and then see that the work is carried out.

Every institution consists of departments, each one being anxious to get the best results. With co-operative effort and a little initiative, the engineer should be able to find the needs and requirements of each department, then make effort that these wants are taken care of and that his own department is in tip-top shape before fall. Heat, light and water are essentials and must be supplied every day in the year, safely, continually and economically. It is up to the engineer, therefore, to think over and plan his work six months in advance.

First; boilers and auxiliaries should be put in first class condition; all the attachments examined and tested; the water softeners and heaters repaired and cleaned; and all sections of the engineering department cleaned, painted, and rooms white-washed.

Second; examination should be made of the heating main and expansion joints, noting the supports and condition of the covering. One of the best ways is to note all repairs in a book, then date and check each item when the work is done.

Third; regulating and reducing valves, steam traps, drips, and bypass valves should be examined and repaired.

Fourth; return pumps, circulating pumps, vacuum regulators are to be repaired, strainers cleaned and all main valve stems packed.

Fifth; examine the heating system in each building, and give special attention to the pitch of the radiators, the condition of the supply arms, packing of the radiator valve stems, the cleaning and repairing of the radiator valves, traps and air vents on radiators and mains. If radiation or piping show signs of corrosion, see that an order is issued to the painting department and that the work is done.

Workmen should be careful to avoid marking up the floors or side walls when making repairs, for this work can be neatly and carefully done. Be sure that all parts are replaced in order to avoid damage when the steam is turned on again.

Many buildings are equipped with automatic temperature control systems consisting of thermostats in individual rooms controlling diaphragm valves on direct radiation in rooms and with control diaphragms for motors attached to dampers in the heat flues of the indirect heating system. When ventilation systems are used, thermostats are placed in the cold air inlet and in the fan discharge, controlling temperature stacks and the bypass dampers. These thermostats should be in the proper location and so connected that there is the least possible vibration.

*Chief Operating Engineer, University of Wisconsin.

If the system in your charge is being operated without mechanical temperature control, I would suggest that you make a study and an estimate of the cost of a system with mechanical temperature control. You can safely guarantee a saving of 20 to 25 per cent of the coal pile if you keep such equipment in repair.

How often in very cold weather, when your boilers are working to the last notch, have you wished for a little more steam for the northwest wing of the building when the south end had more than enough? With a thermostatic system in good condition, the thermostats would close off the radiator valves on the south side where it is warm and divert that steam to the north side where it is needed.

While such a system is automatic in action it needs care. At this time of the year, ask manufacturers to send bulletins and lists of repair parts on your equipment, then place your order for necessary gaskets, diaphragms, springs, discs, and use them before October 15. If you order the material late, you may be disappointed in not getting the material in time. Thermostats, diaphragms, valves and other parts of the system are not complicated, despite popular ideas to the contrary and, with a little practice, you will be surprised how easily repairs and adjustments can be made, but such work should be done by someone who is familiar with the equipment.

Manufacturers of thermostatic equipment are ever improving their equipment; they too are eager to see that their system is working satisfactorily in your charge, and many times their improved devices can be easily installed in your equipment at low cost and will give you good results.

One of the excuses given by engineers for allowing the temperature control system to run down is lack of help. Often the engineer hesitates to ask for sufficient funds to repair the system when it is out of order. Such hesitation to me expresses a lack of interest, knowledge and courage and is usually the reason that such equipment does not work.

If the ventilating equipment is motor driven, now is the time to examine the motor, armature clearance between the poles, the motor brushes and bearings and the fan shafting. It is good practice to clean out all oils from the bearings and refill with good quality oils. See that oil cups and piping to bearings are clean and accessible. Give special attention to the safety devices or guards near fan and motor so that an attendant will not be injured.

If the main shut-off valves are out of reach, either provide a permanent ladder to the valve or install a rim chain to the hand wheel. I find that the reason so much of the equipment is not taken care of is because light is insufficient in the ducts or in the fan rooms for work to be done properly. Often the workman will not get near the equipment to take care of it because the place is cluttered up with belts or because everything is covered with dirt and grease. The fan room should not be used for storage purposes and all rubbish should be cleaned out at once to lessen the danger of

fire. The outside air inlet door should be refitted from time to time and the areaways should be covered with ½-in. mesh screen to prevent waste paper and leaves from collecting in the fan room.

Many times the management finds it necessary to alter the size of the rooms. This necessarily changes the radiation and often spoils the effective use of temperature control and effective ventilation. When it is found necessary to change the size of the rooms, the engineer should rearrange the heating, so that sufficient radiation is in each room and the air lines are taken care of. It is important to see that the thermostat is properly placed and *not covered up* by a shelf or bookcase, also that, after rearrangement, the thermostat is not found to be in an adjoining room.

To obtain the maximum results from any heating system, you must have sufficient equipment to carry away the returns to the heater or boiler and means of removing air. You should carry uniform pressure and have recording gages to verify such operation.

If you are generating current, make use of all the exhaust steam possible to heat the hot water for the institution. Now is the time to clean the heaters and take care of the controlling devices. It is practical and economical to install temperature control devices on your hot water heating apparatus. One of the wastes in an institution is caused by leaky hot and cold water valves, especially the blow-off valves on a boiler. These valves need constant attention, for leaks mean dollars and cents.

Recording Devices

To obtain correct pressures on a heating system, recording pressure gages should be installed at the station and at the far end of the system. A long distance recorder will give the operator at the station the best guide, will assist him to know what pressure is needed, and perhaps prevent a freeze-up, the repair of which is often expensive.

The heart of a power plant is the steam-flow meter equipment, which should be indicating, integrating and recording, from which operating records are obtained. To operate a plant without these important instruments is like running a clock without hands.

Daily comparisons of readings often reveal startling losses. If monthly results are tabulated and then compared from year to year, you can readily see whether you are improving the service or not.

Portable condensation meters are of value to an institution. They can usually be installed at a low cost in a department or building and, if accurate records are kept, you can find out the quantity of steam used to heat such a building and how much it costs for a year.

Perhaps a building has poorly equipped windows or doors that are propped open, or perhaps the windows are left open many hours of the day when the room is not occupied. By finding the causes of the waste, and making the necessary changes or repairs, extra work at the power plant is lessened, also the burden on the heating system in general.

Supplying Refrigeration in a Candy Plant

Large Refrigerating Capacity Required for Air Conditioning in the Candy Plant of the United Drug Co. at St. Louis. By Geo. M. Kleucker*

LARGE IN ITS scope of manufacture, the United Drug Co., known for its production of pharmaceutical drugs from which over 10,000 Rexall Drug Stores receive their supplies, also manufactures candy goods on a large scale. In 1920 this company opened up for production a new large plant in St. Louis which incorporated mechanical equipment of the latest design. This plant is operated under the direction of H. D. Eberle, general manager.

The new plant, being more centrally located, is in a better position to cope readily with the demands for supplies to the warehouses and distributing points in Chicago and San Francisco.

Three large buildings outside of the boiler house constitute the St. Louis plant constructed all of reinforced concrete, the main building being 430 ft. long, 80 ft. deep and seven stories high, outside of the basement, while two wings adjoining are 100 ft. deep by 200 ft. and 160 ft. wide respectively, both also seven stories high outside of the basement.

Over 100,000 sq. ft. of floor space is occupied for the manufacture of candies to the extent of about 7,000,000 lb. annually.

All the power required in the plant is derived from electric motors, amounting to about 750 connected horsepower, the current being supplied from the local public service company, while three water tube boilers of 308 hp. each furnish the steam for cooking purposes as well as heating the building in winter.

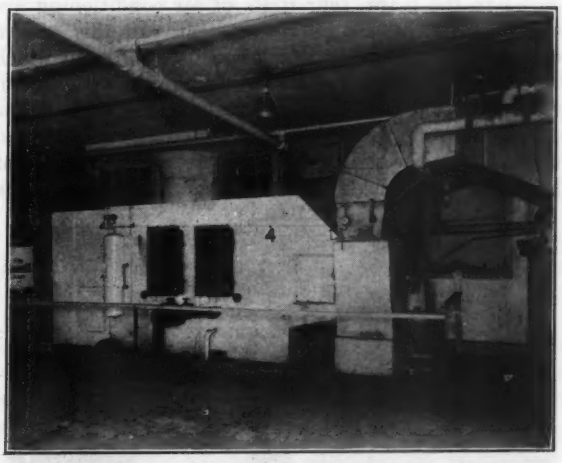


FIG. 1. CARRIER AIR CONDITIONING APPARATUS, SHOWING THE WATER SPRAYS

As it is of utmost importance for a uniform high quality in candy manufacture to have the air in the working rooms as well as store rooms thoroughly purified and washed, it passes through air conditioning systems from which it is delivered to the rooms with the

*Western Dist. Mgr. The De LaVergne Machine Co., N. Y.

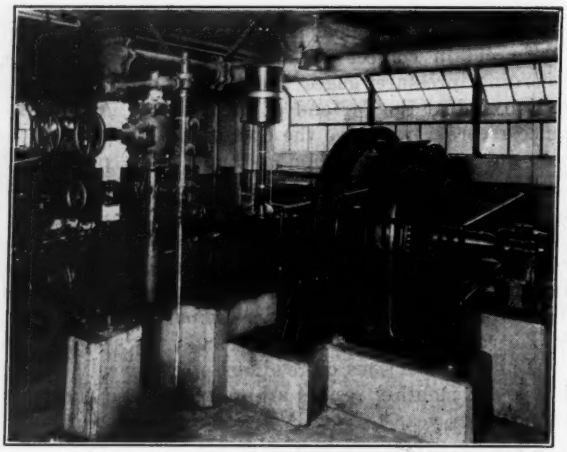


FIG. 2. ONE OF THREE 125-T. DE LA VERGNE REFRIGERATING MACHINES

proper degree of moisture content, which together with the uniform temperature is thermostatically controlled throughout the year inasmuch as the condition of the outside air varies continuously.

Large ducts are provided to supply the different rooms with a continuous amount of purified air from the conditioning apparatus while return ducts from the rooms deliver it back to be rewashed and reconditioned after which it is recirculated together with a certain amount of fresh air taken in from outside which also passes first through an air washer before being admitted into the rooms.

To dehumidify the air, it is necessary to lower its moisture content for which mechanical refrigeration is required.

There are two kinds of air conditioning systems employed in the plant, four units of air conditioning apparatus being of the Carrier system. In this system several banks of spray nozzles are used through which water at low temperatures is atomized and as this temperature is lower than the dew point temperature of the entering air, the temperature of the latter and its moisture is lowered to the dew point. After this a portion of the vapor is condensed by surrendering its latent heat to the water until the desired final temperature of the leaving saturated air is reached.

In winter when the humidity of the air is low, it passes also through a tempering coil in order to bring it up to the required moisture content and room temperature. In addition to the above-mentioned air conditioners there are two Benz installations, using direct expansion coils for refrigeration arranged in bunker rooms. Water is continuously showered over these coils while the air passes through a shower of cold water, coming at the same time in contact with the cold wet pipe surfaces where it gives up its moisture content, at the same time being thoroughly washed. For humidifying the air, it is treated in a similar manner as above described for attaining the moisture content and room temperature.

The water used in the conditioning apparatus averages in temperature from 33 to 35 deg. F., being cooled down to this temperature by refrigerating machines.

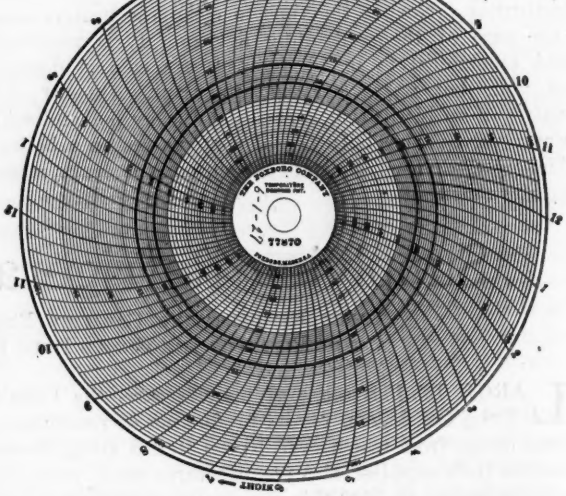


FIG. 3. CHART SHOWING DRY AND WET BULB THERMOMETER RECORD OVER A PERIOD OF 24 HR. NOTE UNIFORMITY OF THE TEMPERATURES

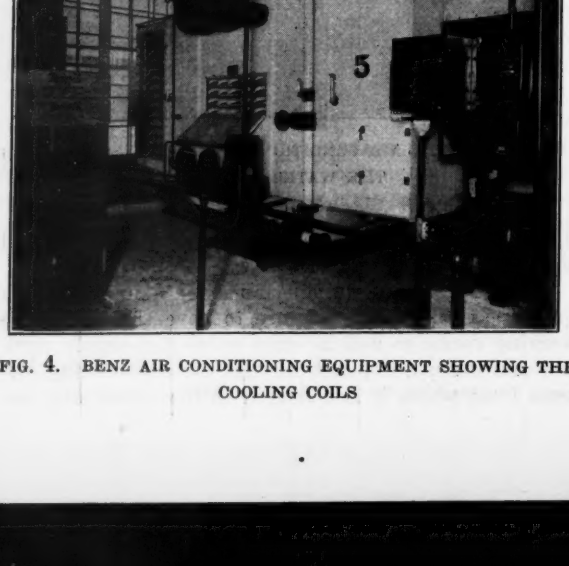


FIG. 4. BENZ AIR CONDITIONING EQUIPMENT SHOWING THE COOLING COILS

Three ammonia compressors of the De LaVergne Machine Co.'s high speed type are located in the engine room of the basement which take care of the refrigerating work, each having a capacity of 125 tons. These machines are operated from 150-hp. synchronous motors, two being belt driven while one is direct connected, the motor being mounted on the main shaft of the compressor.

For the water cooling, open coolers of the Baudelot type are provided over which the return water from the air conditioners is showered at a temperature of about 45 deg. and after being recooled is collected underneath the coolers in a large tank, whence it is pumped back to the air conditioners.

The Baudelot coolers operate on the so-called flooded system in conjunction with a large accumulator or liquid trap, which at the same time serves as an ammonia liquid precooler. In order to work the coolers most efficiently they are kept free of ice at all times,

special provision being made for defrosting by hot gas connections from the machines. The room housing the Baudelot coolers is cork insulated.

It has been found that most satisfactory results are obtained by operating the machines with 30 lb. gage on the suction side while the condenser pressure in summer is 175 lb. gage, the condenser water being recooled with a Wheeler type atmospheric cooling tower.

Counterflow double pipe ammonia condensers are used, being located together with liquid receiver in the basement adjoining the engine room.

Great care is taken to insure and maintain an absolutely uniform temperature and a certain degree of humidity throughout the year both in the working rooms and stock rooms where the finished products are stored. Temperature readings of the dry and wet bulb thermometer are taken every two hours throughout day and night from Foxboro recording thermometers and also Tycos hygrometers.

Twice a year the ammonia compressors are gone over and inspected thoroughly. At these times pistons and valves are taken out, the latter being of the multiple ring plate type, and as indicator cards are taken from time to time the machines are always kept in first-class working condition. Each compressor is provided with a central lubricating system which copiously supplies all the wearing parts with lubricating oil while the piston rods which are packed with metallic packing are provided with force feed lubrication.

A machine shop is located in the basement in which all kinds of repairs are taken care of while also new apparatus of their own design for special machinery is built on their premises.

Dry Ice

USE OF THE heat absorption quality of a solidified gas directly instead of as a refrigerant in the customary process has recently been developed by Arthur D. Little, Inc., of Cambridge, Mass.

Carbon dioxide, the waste product of heating and steam power plants and of various fermentative processes, has recently attained new importance in the refrigeration field. Its use in solid form under the name of "dry ice" is not to be confused with the well-established process of using the gas as a working fluid in the usual type of compression refrigerating system. All machinery at the point of consumption is eliminated and solid blocks of the dry ice are used in much the same manner as ordinary ice.

Certain important differences, however, between the "dry ice" and ordinary ice make it peculiarly adaptable to special conditions. Instead of melting to a liquid, it evaporates directly to a gas, so that it is always dry and clean. Its "melting" or rather evaporating temperature is 146 deg. F. lower than that of ordinary ice. Finally the gas has a slight germicidal property which might be useful in certain cases.

Transportation of perishable food products which must be kept frozen is the most obvious use for this material. The present cost of "dry ice," 5 cents per pound wholesale, is only about three times the cost of an ice and salt mixture, counting the additional handling cost on the latter, while the low temperature, cleanliness and increased capacity available in a car will in many cases so far offset this as to show a handsome profit. A second use is in shipping small quantities of such products as fish and ice cream to distant points. This field is being actively developed to the great advantage of retailers of these products.

Science and medicine will benefit much by the development of "dry ice" because it furnishes a convenient source of refrigeration far colder than ice, and far cheaper than liquid air, which is at present indispensable in many lines of research. It is also possible that a number of important chemical processes, which have hitherto been restricted to laboratory operation by the high cost of producing and maintaining very low temperatures, will be made commercially practicable on a large scale.

Dry ice cannot be expected to replace the older methods of refrigeration to any appreciable extent, but as a supplement to them it promises to find an important field of its own in which to extend the usefulness of refrigeration.

Power Losses Outside the Power Plant

IN A CAMPAIGN to save fuel, the power plant is the center of attention but often greater savings may be made by correcting outside losses. These are frequently overlooked because invisible, seem inconsequential because each one may be small, but the aggregate is frequently in excess of the loss in the boiler plant.

Metering the power and steam supplied to each department and charging for the service is probably the most effective way to insure cooperation in attaining power economy. Transmission equipment, especially if some time in use, may show 15 per cent loss or more. Motors running idle or greatly underloaded are inefficient. Useless burning of lights wastes power. Steam and hot water thrown away are fuel wasted. In some cases expense to reduce losses is greater than possible savings but the leak should be known and accepted as the lesser of two evils, not remain unrecognized.

Use of Reclosing Equipment on A.C. Lines

A. E. ANDERSON, the author of the article under the above title, the second part of which appeared in the August 1 issue, has directed our attention to several errors which occurred due to the splitting up of a diagram. Under the running head Device No. 101 on page 826 the second sentence should state Fig. 2 instead of Fig. 1. Also in the following sentence, the reference to Fig. 2 should read Figs. 2 and 3.

On page 827 in the last paragraph, in connection with device No. 179, reference is made to Fig. 4. Because of space limitations the cut of device No. 179 was taken out, so this reference is incorrect. Figure 4 shows the motor operated mechanism as stated in the caption which is correct. Finally, in the second sentence of the last paragraph, the reference Fig. 1 should reads Figs. 1 and 2.

A DOUBLE leather belt will outlast three singles and will transmit more power at less cost.

Miniature Niagara Shows Flow Control Methods

INTERESTING MODEL BUILT BY NIAGARA FALLS POWER CO. SHOWS EFFECTS OF COMPENSATORY WORKS IN RESTORING BEAUTY OF FALLS AND PERMITTING DIVERSION OF MORE WATER FOR POWER

IT IS 30,000 yr. or more since the Falls of the Niagara began their slow but titanic journey upstream from the escarpment along the old shore line of Lake Ontario. Today, as we are charmed by the grandeur of the falls it is difficult to realize that they are still moving. During the last 150 yr. the erosion and recession have been closely observed and measured. Authentic surveys and records indicate clearly an average recession in the throat of the Horseshoe falls of 6 ft. a year since 1764.

At the present time the Horseshoe fall is wearing away much more rapidly at the center of the horseshoe than it is at the sides, an action which in late years has caused these falls to lose much of their original beauty. About 85 per cent of the flow is concentrated in the middle third of the horseshoe. This uneven erosion and not the diversion of water for power generation is responsible for the declining beauty of the falls.

VIEW OF MODEL BELOW FALLS

To restore the original beauty of the falls and at the same time make available more water for power purposes, it has been proposed to build regulating works, either in the form of invisible weirs in the river above the falls or by the construction of islands to guide the water evenly over the crest of the falls.

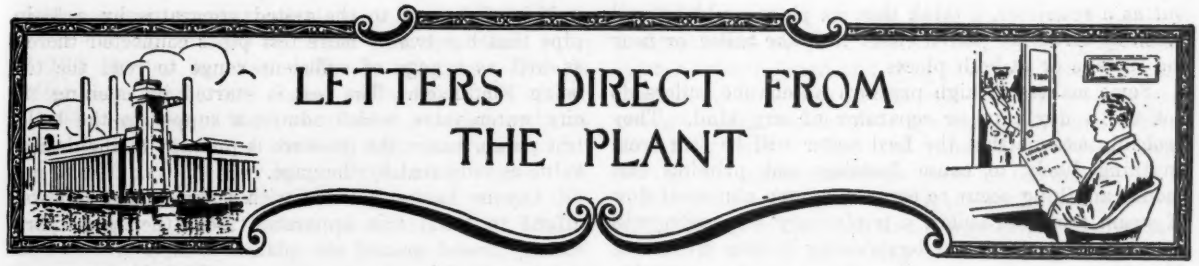
To show what could be accomplished in this manner, the Niagara Falls Power Co. has constructed a small model of the falls, which during the summer has been demonstrated to the public. Located at the rear of the Niagara Plant on Buffalo Avenue, the model has been a center of interest. It is built exactly to scale and affords an excellent means of conducting experiments in stream control. Before the eyes of visitors, men wade out into the upper river to place the weirs and islands.

Water is caused to flow over the model in relative proportion to the actual flowage of the river. Twin loud speakers and a microphone enable the man in charge of the demonstration to explain what is being done and call attention to the effect. A compressed air line under the miniature cataract puts on the finishing touch by providing the spray.

To show the former locations of the crest of the Horseshoe, two wires are supported by rods as shown in the photograph. These wires indicate the locations of the crest as shown by surveys made in 1764 and 1842 respectively. The apex of the Horseshoe was approximately 900 ft. farther downstream when the first survey was made in 1764 than it is today.

The model illustrates effectively that 100,000 cu. ft. of water per sec. could be diverted for power purposes instead of the present 56,000, and at the same time the beauty of the falls could be enhanced considerably.

For the photographs shown herewith we are indebted to Power Events published by Buffalo, Niagara & Eastern Power Corp.



Reducing Lubrication Troubles

SEVERAL of our direct connected blowers were extravagant in the use of oil. A close examination of the motor bearing next to the blower showed that the oil was drawn through the bearing by the suction of the blower. The shaft between the motor bearing and the blower runner was covered with a film of oil. This loss of oil made it necessary to lubricate this bearing every day instead of once a week. To stop this waste, we cut leather disks large enough to fit tightly on the shaft as shown in Fig. 1. The disk acts as a shield and prevents the suction of the air from pulling the oil film along the shaft and into the fan.

Figure 2 illustrates how the leather disk "D" is assembled on the shaft between the motor and blower

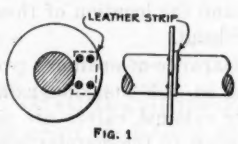


FIG. 1

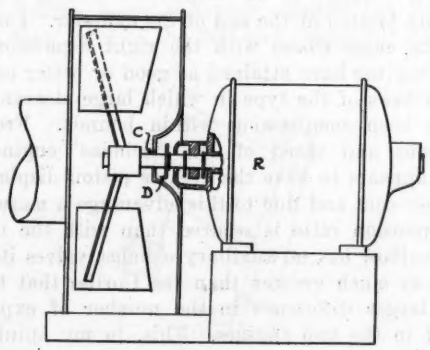


FIG. 2

FIG. 1. SHOWING METHOD OF FASTENING LEATHER DISK TO SHAFT

FIG. 2. SHOWING HOW DISK IS ASSEMBLED BETWEEN MOTOR AND BLOWER AND HOW THIS DIVERTS AIR DRAWN IN BLOWER AROUND SHAFT

and shows the clearance between the blower casing and shaft through which oil was sucked after passing along the shaft from the oil reservoir R.

This method was successful in all but one case. In this case the fan casing was so close to the motor bearing that the end play of the shaft caused the leather disk to work up against the fan and wear until it did not act as it should. The oiler solved this problem by means of the device shown in Fig. 3.

This apparatus consisted of an airtight drum of 2-in. pipe R with a drain D in the bottom cap. From this drum an oil line O leads to the overflow fitting E. As soon as the oil in the overflow E gets below the bottom of the oil pipe, bubbles of air go up the pipe and let enough oil down to raise the level of the oil in the overflow E until the oil pipe is again sealed. The success of this device depends on the accuracy of pipe-

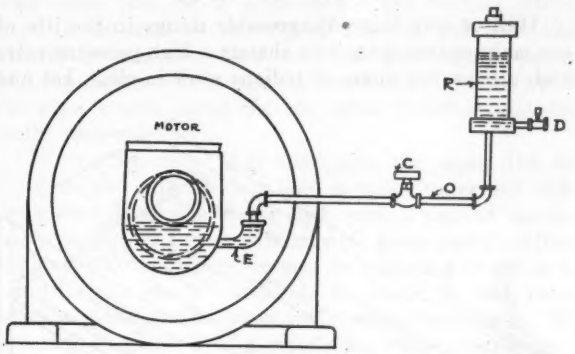


FIG. 3. SHOWS HOW AUTOMATIC OIL RESERVOIR WORKS

fitting done. Air leaks in the piping will cause the oil to run out entirely. A small try-cock is located in the drain D in order to ascertain when the reservoir needs refilling, the cock C in the delivery oil pipe being then closed, the plug in the top cap removed and the reservoir filled. This little device makes it possible to go all week without adding oil, whereas it used to require a supply of oil every day.

Moline, Ill. ROBERT ALTHAUS.

Dry Pipes

THERE SEEMS to be considerable difference of opinion as to the value and purpose of the boiler dry pipe, or as it is known by marine engineers, the priming pipe. Usually it consists of a tube closed at both ends, connected at its center to the boiler drum steam outlet, the top half of its surface being perforated with small holes.

Some boiler makers regard the dry pipe as a dry steam collector, and in their case the dry pipe will extend nearly the whole length of the drum, and the combined areas of the holes in it will greatly exceed the area of the steam outlet from the boiler. Other boilermakers favor a dry pipe a few feet in length. The combined areas of the holes in this case will be considerably less than the area of steam outlet from the boiler.

When the flow of steam from the boiler is normal, this latter type of dry pipe will not appreciably restrict the flow. But should a valve to an engine or turbine be suddenly opened or a break in the steam line occur, it will act as a restrainer, and prevent violent priming. As a steam collector the dry pipe may do some good,

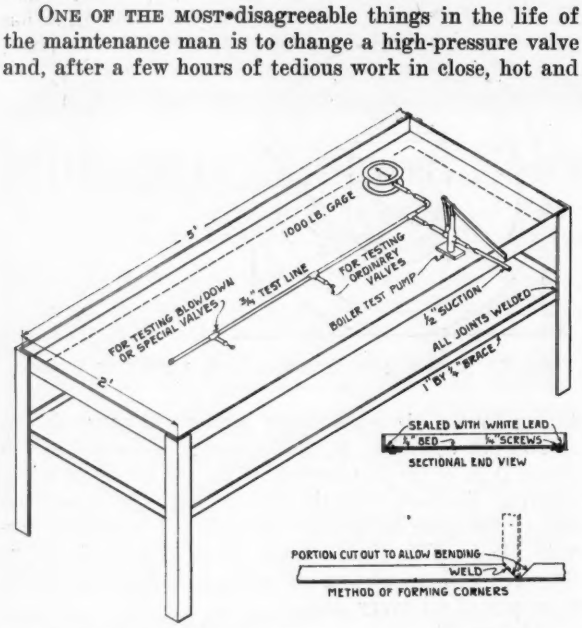
but as a restrictor, I think that its place could be well taken by an orifice placed either near the boiler, or near the turbine or at both places.

Some makers of high pressure water-tube boilers do not use a dry pipe or separator of any kind. They probably assume that the feed water will be free from anything likely to cause foaming and priming and should anything occur to cause a sudden abnormal flow of steam from the boiler, a triple duty stop valve will automatically close, and temporarily isolate the boiler. The dry pipe can cause a lot of trouble, however, due to the holes in it getting choked with dirt, thereby interfering with the flow of steam from the boiler.

Long Beach, Calif. E. J. JORDAN.

Valve Testing

ONE OF THE MOST disagreeable things in the life of the maintenance man is to change a high-pressure valve and, after a few hours of tedious work in close, hot and



APPARATUS FOR VALVE TESTING CAN BE EASILY AND CHEAPLY BUILT FROM SPARE PARTS

dirty places, find that the valve is defective through injury, poor facing in the machine shop, or for some other reason.

True, this seldom happens as such apparatus receives careful inspection but once is enough to make even the most pious man feel like breaking one or more of the commandments. To obviate such trouble it is easy to construct a valve-testing apparatus at low expense that not only will guard against these troubles but has the added advantage of being available for the shopman to test his finished work and for general testing of various types of valves and other items.

The construction begins with the table: A 2-in. angle iron is formed into a rectangle to take a ¼-in. plate 24 by 60 in. which will be held in place by ¼-in. screws and sealed with white lead. The legs are of 2-in. angle iron of convenient height, braced by a ¼ by 1-in. strap which, like the remainder of the construction, is welded. A ¾-in. pipe welded into one and acts as a drain pipe.

City water is admitted to a boiler test pump through a ½-in. line and to the tested apparatus by a ¾-in. pipe that has two or more test pipes connected thereto as well as a gage of sufficient range to read the test being conducted. The test is started by opening the city water valve, which admits a supply to the boiler test pump, where the pressure is pumped to the desired value as indicated by the gage.

Anyone having trouble with leaky valves can well afford to build this apparatus from the spare parts usually found around the plant.

Aurora, Ill. E. J. MORRISSEY.

Counterflow and Uniflow Noncondensing Engine Economics

ON PAGE 798 of the July 15 issue, A. J. Nicholas brings up an important point in comparing the relative economy of noncondensing Corliss and uniflow engines, but I do not quite agree with his reasoning in assigning the cause for the lower efficiency of the uniflow. Of course the assumed increase in efficiency for the Corliss due to steam jacketing must be accepted without argument. Nothing was said regarding the steam tightness of the valves and pistons but we may be sure they were tight on the Corliss or else a horsepower on 21 lb. of steam could not be attained. It would help somewhat to know if the uniflow was equipped with auxiliary exhaust valves and the location of these valves in respect to the cylinder head.

Excessive clearance at ordinary pressures is the great inherent defect in the noncondensing uniflow engine, unless auxiliary exhaust valves are used, in which case there is a reversion to the counterflow principle if these valves are located at the end of the cylinder. I can cite numerous cases where with the right expansion ratio Corliss engines have attained as good or better economy than uniflows of the type in which large clearances are used to keep compression within bounds. From the dimensions and speed of Mr. Nicholas' engines, the Corliss appears to have the greater piston displacement by 25 per cent and due to this advantage a more favorable expansion ratio is secured than with the uniflow. If the uniflow has no auxiliary exhaust valves its clearance is so much greater than the Corliss that there is a still larger difference in the number of expansions realized in the two engines. This, in my opinion, accounts for the better performance of the Corliss for equal steam conditions.

The seven losses in steam engines are as follows: 1. Initial condensation, 2. Incomplete expansion, 3. Wiredrawing, 4. Leakage, 5. Friction, 6. Radiation, and 7. Clearance loss.

The uniflow principle applied to noncondensing engines reduces only the initial condensation loss, and this is not a net gain as the losses due to clearance and incomplete expansion are increased. The expansion cannot be carried down to the back pressure without using very large cylinders as the compression line would follow the expansion line so closely that the mean effective pressure would be absurdly low.

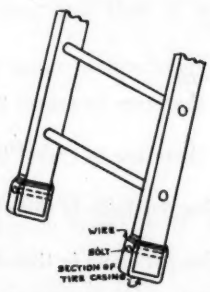
Large clearance can be overcome by auxiliary exhaust valves but these can be advantageously applied only when located at a considerable distance from the cylinder head to prevent the cool exhaust from sweeping over the cylinder head. This method allows smaller

clearance and a smaller cylinder can be used for a given power output. At 150 lb. initial pressure, steam rates of 18.5 lb. per hp. can easily be attained. This is better than counterflow engine performance. We have a 450-hp. uniflow of the type without auxiliary exhaust valves in our plant and the best steam rate claimed by the builder is 21 lb. per hp. using saturated steam. A properly designed four valve engine can attain this water rate and if 100 deg. superheat is used the advantage of this type of uniflow for noncondensing service is very slight. However, for steam pressures of 200 lb. or over and high superheat, a high expansion ratio can be used in the uniflow in which case clearance can be reduced and valves will remain steam tight longer than in the case of a Corliss. The single cylinder Corliss also cannot compete under these steam conditions with the uniflow in the matter of economy. But if we raise the back pressure to 15 lb. or higher the advantage of the uniflow is again lost, all of which goes to prove that careful studies must be made before installing a uniflow and equally careful study should be given to the type of uniflow that is to be installed. For noncondensing service the uniflow with auxiliary valves located away from the cylinder head toward the central exhaust ports has surpassed all others in economy at pressures below 175 lb. saturated steam, and these steam conditions represent what exists in the majority of plants.

Springfield, Mass. A. F. SHEEHAN.

Rubber Feet Prevent Slipping of Ladder

MANY ACCIDENTS occur by ladders slipping. There are, of course, many different schemes for providing against this. One of the best and cheapest I have seen



SECTIONS OF TIRE CASING USED ON FEET OF LADDER, PREVENT IT FROM SLIPPING

is the application of rubber feet made from sections of tire casings. A piece of discarded tire casing is cut the width of the ladder foot. It is drilled in place as shown, to take a ⅜-in. machine bolt. A washer is used on both sides and the outer ends of the casing are bound firmly to the ladder feet with wire.

Syracuse, N. Y. H. L. WHEELER.

Glass Cut Round with Ordinary Glass Cutter

WITHOUT a face glass, the action of a steam gage may be impaired by dust getting into its mechanism. Circular glass cutters that cost only a few cents are on the market but a special device is not necessary for renewing steam gage glasses; they may be cut out by the use of an ordinary glass cutter.

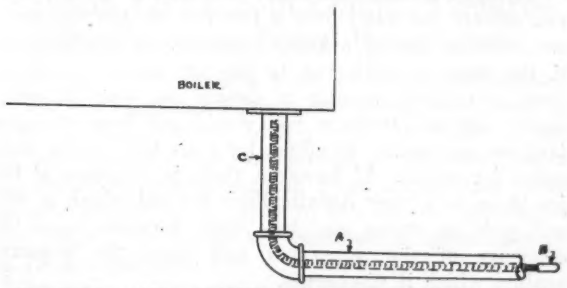
To do this first cut out a circular piece of paper to a size exactly equal to that desired of the glass, place it on a smooth board and then place the glass to be cut over it. Tie a loop in the end of some twine, large enough to slip loosely over a round lead pencil having an eraser end. Wind the other end of the twine around the glass cutter as close as convenient to its cutting wheel. With the pencil placed rubber end down in the center of the disk and a washer placed over and around it to keep the string from slipping underneath the end of the pencil, adjust the loop over the pencil to a length equal to the radius of the disk. The center of the disk and the proper radius may be determined by trial. When the cutting wheel traverses exactly along the edge of the disk, bear down upon both pencil and cutter and mark the glass entirely around the circle but stop when the cut is completed. The cutting wheel may be injured by moving it along a cut that has already been made. Now, turn the glass upside down and tap lightly with a piece of wood along the cut until the glass cracks along the cut, after which it may be easily removed.

If no glass cutter is at hand, glue the paper disk to the glass and after drying, hold it under water and clip the glass off outside of the disk with a pair of shears or tin snips. The glass will crumble away easily. After clipping, the rough corners may be smoothed down on a grindstone or emery wheel. If the latter is used, care must be taken not to crack the glass by heating it. It is better to grind it on a grindstone running in water.

Indianapolis, Ind. JAMES F. HOBART.

Waste Auger Removes Clogged Sediment from Blowoff Pipe

HAVING BEEN allowed to cool off without opening the blowoff cock, the blowoff pipe of a steam boiler was found to be clogged with sediment. The pipe plug was



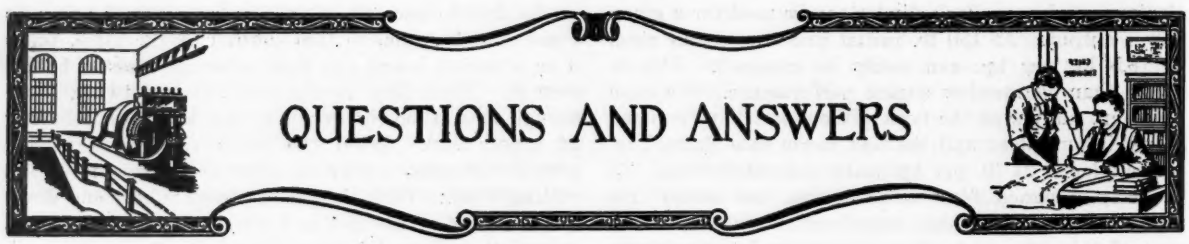
FLEXIBLE AUGER REMOVES CLOGGED SEDIMENT FROM INACCESSIBLE PIPE

removed from the end of the tee on the pipe outside of the setting and the horizontal pipe A, shown in illustration, was found to be clear.

Both air pressure and water pressure were applied unsuccessfully to remove the clogging material. Finally a plumber's flexible waste pipe cleaning auger was forced into the end of pipe at B and, as the handle of the pipe cleaner was turned for about 30 minutes, a hole was made through the sediment which had become packed in the vertical pipe C and the rest of the sediment washed out with the outrushing of the water.

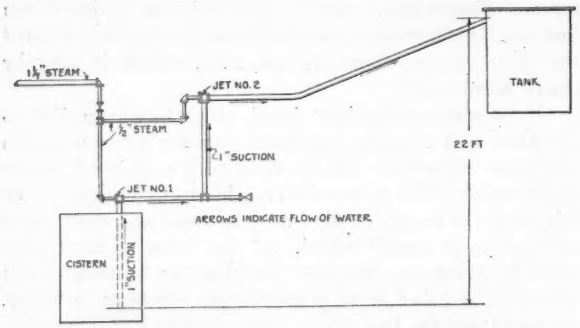
Care was taken to clean out the inside of the boiler before it was refilled with water.

Toronto, Canada. JAMES E. NOBLE.



Pumping by Steam Jet Is Expensive and Limited

IN OUR PLANT we have a system of steam jets for elevating the waste water 22 ft. into an overhead tank as shown in illustration. Sometimes this water is very hot since boiler blowoff water is returned to the cistern.



STEAM JETS FOR ELEVATING WATER FAIL TO OPERATE WHEN TEMPERATURE OF WATER BECOMES 118 DEG.

When the water reaches 118 deg. F. the jets refuse to elevate it to the tank. Can these jets be made to elevate water at any temperature? G. S.

A. You do not state what your suction head is. If you elevate the water only a few feet so that the jet is not working against a heavy pressure and furthermore, if the water is delivered to the jet under a positive head, you should be able to elevate the water at practically any temperature you would get from an open tank as you would, in effect, have air lift, rather than steam jet action. If, however, there is a suction at the jet there is a very definite limit beyond which it will not pick up water and this limit depends upon the efficiency of the apparatus and upon the pressure against which it discharges.

For example: If the water were delivered to a tank 25 ft. higher, the discharge pressure would be about 10 lb. The jet must also get enough water to condense the steam. If it does not, the uncondensed steam breaks the vacuum and stops the operation of the jet.

If the jet will not handle water hotter than 118 deg., we would suggest that you throttle your steam line as much as possible and take a longer time to elevate the water. If this does not materially help, try drawing the nipple down to about ⅛ in. in diameter and cutting it off so that the jet is about in the middle or a little below the middle of the suction opening.

The injector is the most efficient pump of the jet type and by making a special casing, modeled after the injector, you might improve your results. The injector, however, in common with all jet type pumps is extremely wasteful and inefficient and will soon eat up in steam the cost of a small reciprocating pump.

Rate Problem Solved by Simple Algebra

ON PAGE 696 of your issue of June 15 I notice a solution given by Mr. Von Dannenberg of the following problem: "How can I find the rates of speed of A and B under the following conditions? A and B start at a point 300 mi. apart and, traveling toward one another, meet. After meeting it takes A 6⅔ hr. to complete the distance just traversed by B and 15 hr. for B to complete the distance just traversed by A."

While the solution given is correct it seems rather an involved method of solving a comparatively simple problem and the following would appear to be a more direct method:

Let t = time in hours elapsed before meeting
x = A's rate in miles per hour
y = B's rate in miles per hour
Then—
$tx = 15y$
$6\frac{2}{3}x = ty$
Consequently
$t^2xy = 100xy$
$t^2 = 100$
$t = 10$ hours

A's *total* time therefore to travel 300 miles is $(10 + 6\frac{2}{3})$ hours.

B's total time therefore to travel 300 miles is $(10 + 15)$ hours.

A's rate in miles per hour is therefore $300 \div (10 + 6\frac{2}{3}) = 18$

B's rate in miles per hour is therefore $300 \div (10 + 15) = 12$

Schenectady, N. Y. J. AUCHINCLOSS.

Dissimilar Pumps Should Not Be Piped to a Common Suction Line

WE HAVE one No. 5 belt driven centrifugal pump and one steam driven duplex 9 and 8½ by 10-in. pump. Both are working together from a 12-in. suction pipe with no lift and discharging into an 8-in. discharge pipe under 45 ft. head. They do not work satisfactorily under these conditions.

Both pumps are in good condition and either one operates satisfactorily when working alone on the system.

Can you let me know why they do not work properly together? E. S. C.

A. It is not good practice to put two pumps on the same suction line, particularly when they are of two

different types. Even centrifugal pumps on the same line will give considerable trouble and unless the velocity is low it will be impossible to start one pump when the other is running, making it necessary to start up both pumps at the same time if they are to be operated together. The problem is further complicated by the addition of a reciprocating pump and operation conditions are worse because of the fact that the plunger pump will set up pulsation tending to make the centrifugal lose its suction.

Just how much trouble will be encountered depends largely upon the piping layout and velocity in the suction line, which, judging roughly from the size of your pumps, we should say should not exceed 4 ft. per second if both pumps are operating. This is a conservative value in normal practice, but in a layout such as you have, it may cause considerable inconvenience and even damage if you are not able to keep a close watch on them.

Running a separate line from each pump, if possible, would probably solve your trouble, but if you cannot do this, you might make a suction air chamber for the plunger pump and see whether it would help. You can make this chamber with an old tee connection and a piece of capped pipe.

Determination of Size of Water Cylinder to Pump a Given Amount of Water

How MAY I determine the size of water cylinder for a pump having an average piston speed of 100 ft. per min. and pumping 100 g.p.m.? W. S.

A. You do not state the type and kind of pump used so we are assuming it is one whose "slip" may be taken as 5 per cent and that it is a double-acting duplex pump.

The amount of water pumped per min. in cu. ft., Q, will be

$$Q = \frac{a}{144} S \times 0.95$$

where a = area of piston in sq. in.

S = average piston speed in ft. per min.

1 gal. = 231 cu. in.

$$\text{therefore } 100 \text{ gal.} = \frac{231 \times 100}{1728} = 13.38 \text{ cu. ft.} = Q.$$

$$a = \frac{144\,Q}{0.95\,S} = \frac{144 \times 13.38}{0.95 \times 100} = 2.03 \text{ sq. in.}$$

$$\text{area} = \frac{3.1416\,D^2}{4} = 0.7854\,D^2$$

$$D^2 = \frac{\text{area}}{0.7854}$$

$$D = \sqrt{\frac{2.03}{0.7854}} = \sqrt{2.59} = 1.61$$

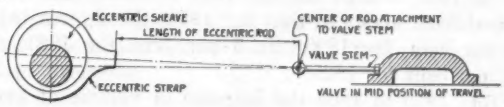
or say 1¾ in. diameter.

It is apparent that this diameter is much smaller than is practical for a pump of the capacity given but this is doubtless due to the fact that the speed given is also much higher than is found in such pumps. The method given, however, is correct and data for other conditions than those given may be substituted for corresponding values in order to solve practical problems of this kind.

Length of Eccentric Rod May Be Obtained by Direct Measurement

WHILE THE answer given to the question concerning the length of an eccentric rod published on page 850 of the August 1 issue is not incorrect, I believe that none but an experienced engineer could obtain the correct length of the rod from the directions given. I am, therefore, submitting the following to make the matter more clear.

To obtain the length of the eccentric rod, the valve should by actual measurement be placed in its mid stroke position and the eccentric placed in the mid position of its extremes of movement as shown in illustration. When in these positions, the distance between



CENTRALIZING THE ECCENTRIC AND VALVE POSITIONS PROVIDES A DIRECT METHOD OF MEASURING THE LENGTH OF THE ECCENTRIC ROD

the center of the valve stem connection and the connection at the eccentric strap end of the rod, will be the required length of the rod.

Brooklyn, N. Y. CHARLES J. MASON.

Suction Lines from Common Source Should Have Equal Resistance

IN OUR PLANT we have a 500-kw. steam turbine connected to a Leblanc condenser and several reciprocating steam units connected to a surface condenser. The cooling water for these condensers is obtained from a salt water channel through an 18-in. suction line. The Leblanc condenser is piped to this suction line by a 6-in. connection; the surface condenser is served through an 18-in. connection.

When the vacuum is increased above 25 in. on the reciprocating condenser the condenser connected with the turbine loses some of its suction water.

What causes this trouble and how can it be avoided? A. M.

A. Unequal resistance in the two suction line connections during the higher vacuum conditions when most water is required, is the cause of your trouble. The best way to correct this is to increase the size of the suction connection to your turbine condenser. If this cannot be done, restriction in the suction connection of the other condenser may be introduced by installing a gate valve in this line and closing the valve more or less as required during periods of high vacuum requirement.

EDITORIAL COMMENT

Horsepower, Wages and Manufactured Product

Considerable of interest is to be found by the power plant executive in the study of figures recently given out by the National Industrial Conference Board. Repeatedly, the effect of increased use of power on working conditions and worker's output has been brought out but the figures give a more concrete comparison and permit following the course of this effect. The now common standard of conditions in 1914 is taken as 100 per cent and results for other years are given as compared to that standard.

Volume of products has shown steady increase from 1899 to 1925, except for the 1921 enumeration, which dropped back about to that for 1914, the figures being 59.2 per cent for 1899, 101.5 per cent for 1921 and 164.7 per cent for 1925.

From 1899 to 1909 the increase in volume of product was greater in proportion than the number of workers and workers gained in output per man. Meantime power used had increased and gain in output was approximately in proportion to this increase, although slight increase in power used per unit of product was shown. Then came a period of lower effectiveness of workers up to 1921 but volume of total product kept increasing because of further increase in power use, the increase being from 44.7 per cent in 1899 to 131.6 per cent in 1919. (Power figures are not given for 1921.) Evidently the increase in use of power was accompanied by slowing down of the individual worker's effectiveness possibly because unskilled labor was more largely employed.

Since 1921, increase in the use of power has been rapid, product per worker has increased almost in proportion to power used and volume of product has increased, so that we have, seemingly, been applying power to good advantage.

In money values, based on the 1914 dollar, product per worker and wages payable increased from 1899 to 1909, then fell off until 1919 and has increased steadily since that time but value of product per horsepower decreased steadily from 1899 to 1919 and has changed little since, the range being small from 1909 to 1925.

Generalizing is somewhat hazardous but the data seem to indicate that from 1899 to 1914 industry was fitting its processes for advantageous use of larger amounts of power per worker so that volume of product increased only with increased man power. With war conditions, reduction in workers came and power was utilized wherever possible to speed production. The 1920-21 slump retarded progress for a time but, with industrial recovery, power was still further utilized to increase production, partly to lower costs, partly to offset the reduction of workers due to restricted immigration. Steadily power gains in importance as a factor in manufacturing, assisting in growth of industries, in larger total and individual production and in bettering the returns to workers in the form of larger wages and decreased cost of the products which they buy.

Plenty of Coal in Sight

In view of the strike still in force in the coal mines of the Middle West, there is considerable interest in the report of the Bureau of Mines on the commercial stocks of coal on hand July 1. This report shows that 62,000,000 t. of bituminous coal were in the hands of railroads, industrial consumers, public utilities and retail dealers. This figure does not include coal for steamships, on lake docks, in transit and in bins of householders. Compared with former years, there is no other July 1 on record when as much coal was on hand as there is this year. Not only that, but the coal production this summer has remained at about the average of the past three years.

Except for the increased production in the early months of this year and consequent greater storage in anticipation of coal shortage due to the strike, the production for the year has been quite normal. Evidently the needs of the country are being supplied without the mines affected by the strike and the country as a whole can cast its worries back upon the shoulders of the miners and mine operators who have not seen fit to agree on terms. At the time of the general coal miners strike in 1922, the statement was made by men well posted on the industry that there were too many coal mines and miners for the needs of the country. This seems to be proving out as a study of the production reports in various sections of the country indicates that the full capacity of the mines that are being worked is not being reached at the present time.

Domestic consumption may bring the demand for bituminous coal up to a point where prices will be unusually high but the coal which was put in storage by different industries last spring will probably prevent anything like a famine occurring this fall.

Diesel Engine Application

Diesel engines have a wide field of application and have done much to better power costs in small and medium sized plants. Cost per unit of power and thermal efficiency are practically independent of the size of the plant. For the smaller plants this offers a distinct advantage over steam plants where the overall thermal efficiency may vary from four or five per cent for small industrial plants up to 27 per cent as at Columbia.

Definite limitations are, however, imposed on this type of prime mover, largely by fuel, labor and water conditions. Diesel engines have been employed to a certain extent by public utilities for central station practice and the conclusions regarding the advantages

of oil engines over steam plants in certain sections of the country can be applied to industrial plants where the problems of process steam and heating do not enter.

In this issue is an article by Mr. Drabelle on the relation of the Diesel engine to central stations. Figures for power and installation costs are given, these being the results of several years' successful operation of both steam and oil engine plants. Probably no engineer in this country is better qualified to discuss the subject.

The Iowa Railway & Light Corp., of which Mr. Drabelle is Mechanical and Electrical Engineer, has 28 steam units amounting to 63,885 kv.a. and 12 Diesel units totaling 6140 kv.a. A considerable number of the smaller steam units are being used only as standby when taking power from transmission lines. All of the Diesel engines are in service, so that the proportional working capacity of the engines is greater than appears from the figures.

Cost figures for two representative plants show that power can be generated by Diesels well under 2c per kw-hr., in small isolated plants even with low load factors and that the guaranteed figures of reputable manufacturers can be relied upon to form a basis of comparison between different types and different engines, although fuel and lubricating costs must not be considered the deciding factor.

Refinement in Details at Stanton

It is within the bounds of possibility that some enterprising newspaper, on learning about the new Stanton Power Station, described in this issue, will forthwith publish an editorial, calling attention to a tendency of some kind or another. Not long ago, a mid-western newspaper, in commenting on the building of a 10,000-kw. central station near the mouth of a mine, solemnly pointed out that this showed a tendency to locate power plants at mine mouths, thus cutting costs of transporting coal and tending to eliminate trouble caused by coal strikes. The fallacies in such reasoning have been pointed out repeatedly.

Yet the new Stanton Station does illustrate a tendency of quite a different kind, to which previous reference has been made. This is the tendency, which will probably be apparent for the next two or three years, toward refinement of equipment and consolidation of the ground already gained in power plant design, without the bringing to light of many new fundamental principles or startling discoveries. It is true that the building of Stanton in such a location that anthracite culm can be easily and cheaply obtained is an important point. Yet the fortunate juxtaposition of fuel supply and condensing water, as found at Stanton, combined with design of a furnace in which this low grade fuel can be successfully burned, is not at all common. Part of it is due, of course, to the research and foresight of the designers and owners of the plant.

It is in the refinement of details, however, that Stanton is of most interest. The division of the plant into two sections to serve two separate transmission lines affects the layout of circulating water equipment to serve the ultimate plant, while the coal conveying equipment lends itself well to extension of the plant. Reasons for employing the air-water economizer between the air preheater and stoker are discussed in some detail in the article, together with data on the soot hoppers, air soot blowers, boiler room cranes and other details.

Control methods at Stanton show many refinements. Since the forced and induced draft fans incorporated in the air preheater are driven by one motor, electric damper controls are provided on the boiler control board for securing proper draft conditions rapidly and accurately. Boiler feed pumps are placed in the turbine room, with suitable controls so that the turbine operators have entire supervision over all water heating and feed water factors, which are inter-related with the operation of the turbine, from which the steam for feed water heating is extracted. Use of across-the-line starting auxiliary motors, controlled entirely by a centralized installation of iron-clad switches, is another interesting control feature.

In short, although in one or two respects the Stanton plant incorporates unusual equipment—such as the furnaces, the air-water economizer, the floating head condenser—its principal interest, it seems to us, lies in the refinement and simplification of details to insure flexible, convenient operation and to supply low cost base load power. Every detail reflects the ingenuity and sound judgment of all who had a part in its design. It is a long step forward, we feel, on the path of power plant progress.

The Poor P. A.

Difficulties between the engineering and purchasing departments are traditional and it was somewhat of a surprise when we came across an engineer recently who had a friendly word to say about the purchasing agent.

This man has charge of the power plant for a large manufacturing company and burns roughly a quarter of a million dollars worth of coal a year. The purchasing department is in a different city and not more than two or three letters a year are passed between the two on this subject.

They have an approved list of coal companies and when coal contracts are to be renewed, bids are solicited from all of them. Companies not on the approved list are referred to the plant engineer who simply arranges to test a carload or two of their coal during the summer when the heating load is off. If they are willing to provide for this, complete tests are made and the coal analyzed. If the tests are satisfactory, the coal is approved and the name together with what it is and what it will do are sent to the purchasing department to be added to the approved list.

Any of the coals on this list are satisfactory to the engineer; the purchasing agent knows what each will do and what it tests and uses his own judgment as to which one is the best to buy. A simple arrangement and one which has worked out satisfactorily for years, entirely eliminating the troubles, difficulties and bickerings existing previously, in addition to saving money, a credit to both engineer and purchasing agent.

"A fairy tale," say the little engineers, pattering off to bed satisfied with the bedtime story. Well do they know that a purchasing agent is a traditional enemy of the engineer and that a friendly purchasing agent is a myth. Nevertheless, the story is true and could well be used as the basis of a truce between the two departments.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Belt Conveyor Uses Anti-Friction Rolls

By W. E. Philips*

INTRODUCTION of its anti-friction belt conveyor idler and return rolls is announced by the Link-Belt Co., and shows a distinct advance in belt conveyor

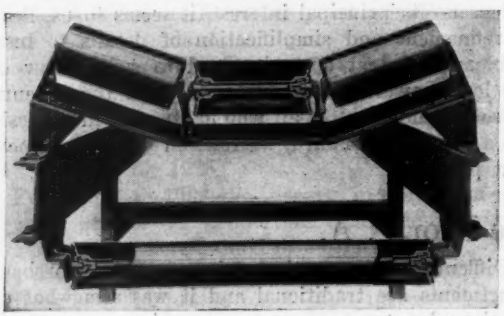


FIG. 1. TROUGHING AND RETURN BELT CONVEYOR IDLERS USE ROLLER BEARINGS

equipment. Many features of advantage in design, the results of years of study and research, are embodied.

As shown in Fig. 1, troughing rolls are mounted on a base made of a structural tee which is arranged to be self-cleaning, all parts of the frame being riveted together so that alinement is permanent. Rolls are interchangeable and can serve in any of the three positions, the only change being in the Alemite lubrication fitting on the center roll. Return idlers are mounted in brackets beneath, which have large bearing surfaces for support, the supporting ends being made with short overhang for both troughing and return idlers, so as to reduce the bending moment on the shaft.

Construction of the bearings is the same for both troughing and return idlers and is shown in Fig. 2. The bearings are of Timken tapered roller type, totally enclosed within the roll hub, with adjustment which is locked in place. A grease seal is provided at the end of the bearing mounted in a grease cap which also serves as an outboard reservoir for grease, the bearings running submerged from both ends in a grease bath. Lubricant is supplied through Alemite industrial fittings in one end of the shaft. Bearings and grease seal are protected by a deflector plate which fits into a recess in the end of the roll and deflects dirt and dust away from the bearings, also prevents the washing of the grease away from the labyrinth. Because of this protection from dirt and grit, close working tolerances are permissible, which makes for smooth running and durability.

In the construction of the rolls special care is exercised to obtain uniform thickness of wall and the machine heads are pressed into the ends of the roll, then securely held by spinning down the edges of the roll, thus giving rounded edges. The dished head makes for rigidity and strength and also carries the roller bearings in under the load which they are to support.

Because of the special design and construction, it is possible to vary the characteristics of the material used for the shell of the roll, a special iron having been developed for use in coke plants which resists corrosive action of sulphuric fumes and abrasion by coke dust; also, rolls have been granitized for handling certain materials

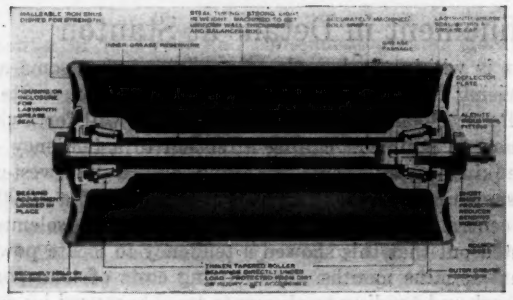


FIG. 2. BEARINGS ARE GREASE FILLED, SEALED AND WITH DUST COVERS

such as salts and alkalis which might cause incrustation or pitting. Spacing between troughing rolls is sufficient to permit convenient removal by simply lifting them from the frame. Idler rolls are made in standard lengths and furnished in combinations to suit standard belt widths.

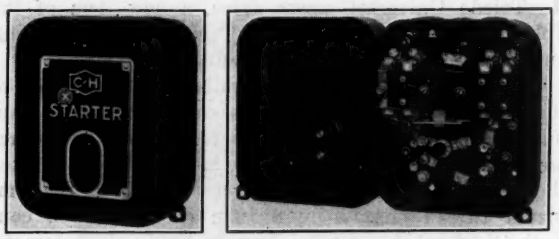
Specially constructed tools and machinery assure the alinement of bearings and well balanced rolls, a building at the Ewart Plant of the company in Indianapolis being especially equipped for the manufacture of this type of conveyor idlers.

*Engineer, Link-Belt Co., Chicago, Ill.

Smallest Across the Line Starter

NO LARGER THAN a telephone box, the Cutler-Hammer Mfg. Co. of Milwaukee, Wis., has recently developed a small across-the-line-starter which is intended for use with motors up to 5 hp. It gives push button control of starting and stopping, provides thermal overload protection and no voltage protection.

As may be noted from the accompanying illustrations, the starter is provided with push buttons in the front cover of the case. The small size in most cases permits mounting of the starter where the control station would ordinarily be placed and the extra wiring and cost of a push button station is thus saved. However, one or more push button stations may be used if desired.



OPEN AND CLOSED VIEW OF NEW CUTLER-HAMMER CO. STARTER

A novel feature is the type of contactor developed for use with this starter. A roller is forced between two fingers to complete the circuit. Thus a double break, and a wiping contact are secured. To adapt the starter for any horsepower within rating it is only necessary to insert the proper size heater coils in the thermal overload relay.

Streamline Air Filter Cleans Itself Automatically

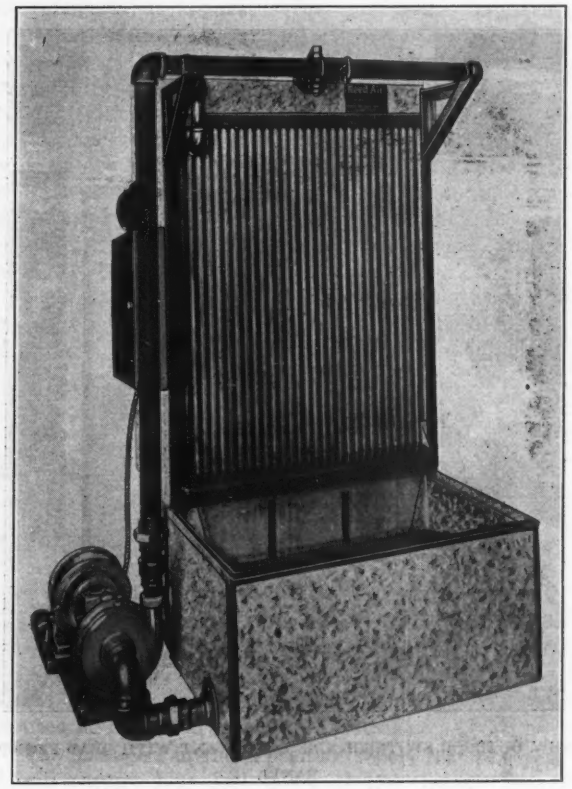
NUMEROUS APPLICATIONS of air filters are made where lack of adequate maintenance facilities makes automatic operation desirable. To meet this requirement, a self-cleaning automatic streamline air filter, as shown in the illustration, has been developed. In this apparatus, the filtering medium is a series of vertical streamline baffles or forms staggered in rows and coated with an adhesive oil for entrapping the dust, with provision for automatically flushing these elements with the adhesive oil to remove the accumulated dust. This flushing oil flows down the elements by gravity and is cleaned and used over again at the next flushing period.

The unit consists of three parts; the filter body, the distributor and the oil cleaner. The only auxiliary equipment is a small motor-driven pump to lift the oil from a reservoir beneath the cleaner and force it into the distributor at the top of the filter.

Streamline forms are of the same general shape as aeroplane struts or braces and are held vertically in the body of the filter. The spaces between them are similar in shape to a venturi tube, this design being intended to give a constant resistance to air flow which does not increase with dust accumulation. Air passing between the forms of the first row impinges on the adhesive coated forms of the next, which collect the dust and allow the air to flow on to the next row and so on through the filter. The resistance to air flow, when the unit is operated at rated capacity, is 0.25 in. of water.

To remove accumulated oil and dust, oil is sent by a pump to the distributor at the top of the forms, whence it flows down over them by gravity, washing the dirt into the cleaner. This cleaner is of the wool-waste type, the oil filtering down through it into a reservoir from which it can be recirculated again by the pump. When the wool-waste pad becomes too dirty it can be easily replaced. The distributor controls the flow of oil over the forms and proportions its volume to the relative dust load.

Automatic or push button control can be applied to the above cleaning arrangement. Since the filter is generally used in conjunction with a fan, the pump motor can be equipped with an electrical device in the fan motor circuit which will start the pump as soon as the fan is shut down and, by means of a time relay, will allow it to run for a given length of time. Thus the filter cleans itself automatically at frequent intervals.

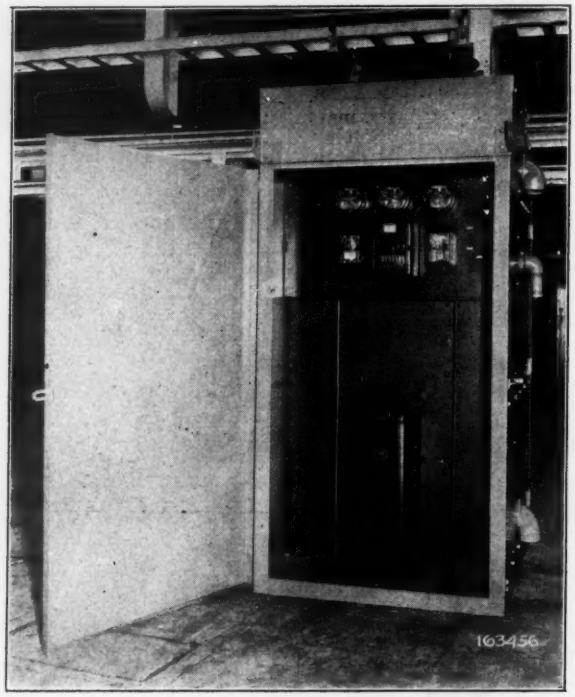


AIR FILTER SECTION OF 6000 C.F.M. CAPACITY, SHOWING FIRST ROW OF STREAMLINE FORMS, OIL PUMP AND OIL CLEANER AT BOTTOM

Unit construction is used throughout this filter, which is manufactured by the Reed Air Filter Co., Louisville, Ky. Filter bodies are made in two heights and two widths. One size 6 ft. high and 1 ft. 7 in. wide, has a capacity of 3000 c.f.m. For 6000 c.f.m., there are two sizes, 6 ft. by 3 ft. 1 in. and 10 ft. by 1 ft. 7 in. For 12,000 c.f.m., the unit is 10 ft. by 3 ft. 1 in. Various combinations of these are used to give capacities from 3000 c.f.m. to 120,000 c.f.m. Each filter is furnished ready for electrical and sheet metal connections.

Inexpensive Outdoor Switchhouses

SMALLER POWER and lighting customers of central stations are continually demanding greater reliability and better continuity of service. Since the revenue from such customers is comparatively small, the equipment to accomplish the desired results must be relatively inexpensive. Many of these smaller power consumers are remotely located and the installation of an outdoor substation would, from the standpoint of cost, be out of the question. In an effort to cope with the above situation, many new developments and perfections of design have been accomplished in outdoor weatherproof switchhouses as these seem to be the most inexpensive means of furnishing the desired results.



NEW OUTDOOR SWITCHHOUSE EQUIPMENT WITH DEAD FRONT PANEL

During the past three months the Westinghouse Electric and Manufacturing Company has made several important and desirable changes in the design of its outdoor switchhouses, the most prominent of which is the reduction in height which gives a more compact single unit and also allows ready mounting under existing structures and busses. Another desirable feature is the complete isolation of the front from the rear of the houses without decreasing accessibility. This assures a unit which is entirely dead front, neat in appearance, and rigid in construction. The meters and relays are now mounted on steel instead of slate panels which also provide additional bracing to the houses as well as eliminating the possibility of panel breakage. The circuit breaker control relay is mounted in a glass case, thus removing all danger of contact with live parts in the front of the house. This enables the central stations to utilize the services of a more or less inexperienced man to obtain meter readings without danger of physical injury from contact with live parts.

Universal Power Drive Operates on 110-V. Circuit

IN THE accompanying illustration is shown the new Toledo Universal power drive, a new item of the Toledo line designed to operate Toledo tools for cutting and threading pipe up to and including 12 in.

This new power drive is similar in appearance to the Junior power drive. It is equipped with ½-hp. universal motor which will operate from a light socket on any 110-v. circuit. The motor is reversible and, after the thread is cut, the operator backs the dies off the completed thread simply by a turn of the switch conveniently located near the driving head. It automatically slows down on the heavy pulls, speeds up on the light loads and thus assures the operator maximum efficiency at all times.

It is easily wheeled about on its strong wire wheels, weighs only 165 lb., is strongly built, simple in construction, easy to operate, and converts hand-operated

FOR SMALL PIPE, THE POWER DRIVE HELPER CAN BE FITTED TO HOLD THE TOOL, THE PIPE BEING HELD IN THE CHUCK

threading and cutting tools into highly efficient power machines.

The Power Driver Helper comprises a special yoke and chuck attachment that is fitted in the driving head of the power drive as shown, to permit the use of pipe threaders and cutters for ½-in. to 2-in. pipe. No vise is required. The cutting or threading tool is put on the pipe and as the pipe is held in the chuck, the current is turned on, the pipe rotates and the threading or cutting tool is held stationary, doing its work quickly. A turn of the switch, the motor is reversed, and the dies are quickly backed off the completed thread. This drive is being placed on the market by The Toledo Pipe Threading Machine Co., Toledo, Ohio.

THE UNITED ELECTRIC LIGHT & POWER CO., 130 E. Fifteenth St., New York, has perfected plans for extensions in its Hell Gate electric generating plant, 132nd St. and East River. The program will include the installation of a 225,000-hp. turbo-generator, for which a contract has been placed with the Westinghouse Electric & Mfg. Co.

New Soot Blower Has Telescoping Element

DESIGNED TO REDUCE maintenance of soot blower elements by withdrawing them from the boiler when not in use, the Lickert-Reedy soot blower shown in the illustrations has been developed. The purpose of such a design is to increase the life of the elements when used in any section of the boiler and particularly when used in the first pass of V-type water tube boilers to clear deposits over the lower drum and on the lower part of the first bank of tubes.

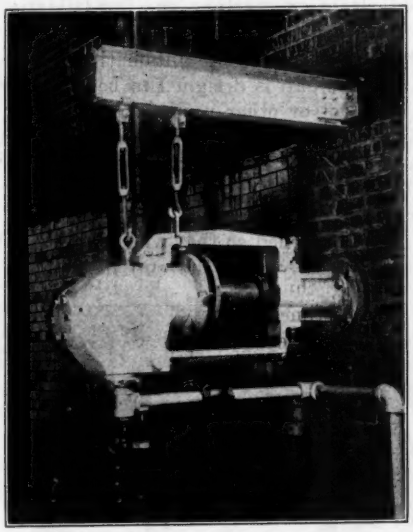


FIG. 1. SOOT BLOWER INSTALLED ON SETTING

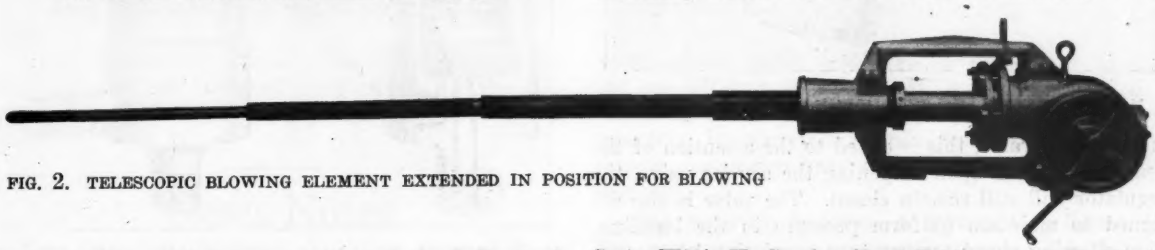


FIG. 2. TELESCOPIC BLOWING ELEMENT EXTENDED IN POSITION FOR BLOWING

To meet these requirements, the blower is designed with a telescoping element. Figure 1 shows the blower installed on a boiler setting and Fig. 2 the element extended in blowing position. The end of the element is closed and when steam is turned on this closed end acts as a piston to extend the element across the furnace. After blowing is completed the elements are withdrawn, telescoping into one another, by a chain inside the elements working over an external drum, which is driven by the crank and gearing shown. Elements are fitted with a capstan head, rotating in a packed gland and stuffing box and permitting complete rotation of the element.

The unit is designed to be easily removed for repair or replacement without taking the boiler out of service and to permit boiler tube replacements without disturbing any soot blower elements. Since the unit is entirely outside the furnace proper when not in use, it is claimed that maintenance charges are reduced.

The blower is being placed on the market by Long Reach Soot Blower Co., Hamilton, Ohio.

Sixth National Power Show Announced

AT THE GRAND CENTRAL PALACE, New York City, the Sixth National Exposition of Power and Mechanical Engineering will be held from December 5 to 10 inclusive, according to a recent announcement. At the same time, the annual meetings of the American Society of Mechanical Engineers and of the American Society of Refrigerating Engineers, will take place.

Number of exhibitors this year is already considerably increased over last year; there are now more than 500 exhibitors. Exhibits will include approximately some 400 exhibits of power generation, distribution and utilization equipment; between 200 and 250 exhibits will include heating and ventilating equipment, as well as refrigeration apparatus for large scale industries, factories, office buildings, apartment, public and assembly buildings, and homes. Between 100 and 150 exhibits will show instruments for control of time, pressure, temperature, volume, or any other property that requires precision in its measurement or recording. There will be about 125 exhibits or more of machine shop equipment, including metal and wood working machines and transmission equipment. There are many new outstanding exhibits of transmission equipment and of materials handling equipment.

The advisory committee of the exposition co-operating with the management comprises: I. E. Moultrop, chairman, Homer Addams, F. Paul Anderson, N. A. Carle, Willis H. Carrier, Fred Felderman, C. F. Hirshfeld, O. P. Hood, John A. Hunter, E. B. Katte, R. T. Kent, John H. Lawrence, Fred R. Low, David Moffatt Myers, R. F. Pack, Fred W. Payne, Calvin W. Rice, Charles F. Roth and Charles M. Schwab.

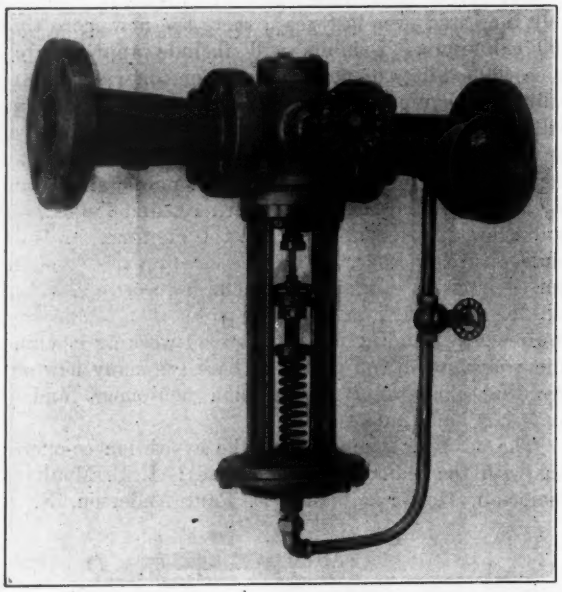
The managers of the exposition report that this year it will occupy four full floors of the Grand Central Palace. All inquiries should be addressed to the International Exposition Co. at the Grand Central Palace, New York, N. Y.

TOTAL PRODUCTION of electric power by public utility power plants in the United States as reported by the Geological Survey, Department of the Interior, for June, 1927 totalled 6,446,300,000 kw-hr. Of this amount 3,919,978,000 kw-hr. were generated by the use of fuels and 2,526,322,000 kw-hr. by water power. The total output shows an increase of 9 per cent over that for June, 1926.

GEO. W. IREY, Production Supt., The Ohio Public Service Co., Lorain, Ohio, has been transferred in a similar capacity to the Empire District Electric Co. with headquarters at Joplin, Mo. His mail address will be Riverton, Kansas.

Mason Reducing Valve for District Heating

FOR USE IN DISTRICT HEATING SYSTEMS in connection with the distribution of steam to individual customers, the reducing valve unit shown herewith has been developed. One of its principal advantages is in permitting reduction in size of mains from the heating plant to the building where steam is used for heating. In addition, when a customer closes the



MASON REDUCING VALVE, SHOWING BYPASS AND GAGE

main service valve, this is called to the attention of the heating plant, as upon reopening the service valve, the regulator will still remain closed. The valve is also designed to maintain uniform pressure in the building, thus allowing closer temperature regulation by the improvement in operation of the customer's regulating valves on various apparatus. Finally, it is intended to help the heating company in giving good service by providing a constant pressure at the flow meter, thus giving a true meter reading.

Connections between diaphragm and main valve are direct. Use of a balanced valve reduces to a minimum any variations in the low pressure main caused by those in the high pressure. The reduced pressure is obtained by adjusting the spring until the gage shows the desired pressure. This adjustment is made when the valve is installed; it is then covered by a perforated metal guard to prevent unauthorized adjustments. Valves are designed for 125-lb. pressure, although a construction for higher pressures can be provided. Valve member and seat rings are of hard bronze, or where service is especially severe, of a nickel composition. Diaphragm is of molded rubber about ¼ in. thick with two insertions of duck or canvas reinforcement.

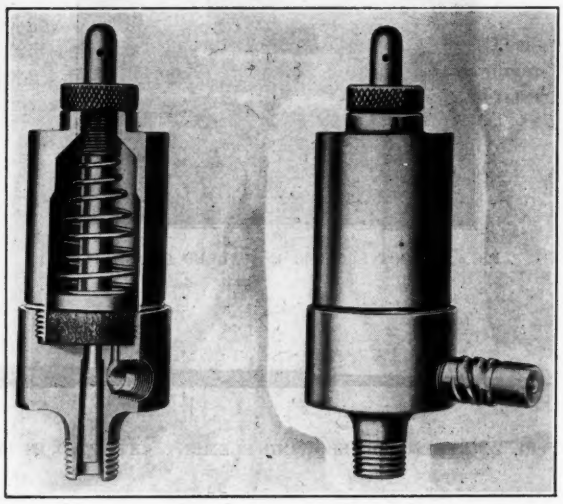
To facilitate servicing these units or changing sizes of valves to suit changing loads, the flange diameters and face-to-face dimensions of the units are the same for all sizes. A bypass is provided for starting up the system after steam is shut off.

These valves were developed especially for district heating service by co-operation of D. S. Boyden, superintendent of steam heating service, The Edison Electric Illuminating Co. of Boston, with The Mason Regulator Co., Dorchester Center, Boston, Mass.

Dot-O-Matic Pressure Cup

DESIGNED TO ASSURE smooth constant delivery of lubricant to bearings, the Dot-O-Matic pressure cup has recently been put on the market. This is made in two types, the adjustable automatic and the regular automatic. The cup is designed to be filled with lubricant from a Dot or other pressure grease gun or tank, engaging with the filling nipple on the side of cup. The accompanying illustration shows a sectional view of the cup at the left and at the right an exterior view showing the filling nipple.

The cup is designed so that when lubricant is forced in it enters directly into the cup instead of into the



LEFT: TAPERS ON VALVE SEAT AND STEM DESIGNED TO COMPENSATE FOR VARYING SPRING TENSION. SPRING ADJUSTABLE FOR FAST OR SLOW FEED. RIGHT: CUP IS FILLED FROM PRESSURE GUN THROUGH FILLING NIPPLE AT SIDE

delivery passage, first filling the reservoir and then gently slushing the bearings. Pressure on the lubricant is provided by a spring, the tension of which is adjustable by the knurled nut at the top to give fast or slow speed. A tell-tale projecting through the top shows the rate of feed, while the combination of tapers on the valve seat and on the stem is designed to compensate for the varying tension of the conical spring. A special shoulder inside the valve is intended to prevent maximum compression or set of the spring. The adjustable automatic type of cup is designed to deliver its contents in from 1 to 7 days; the automatic type, which does not have the adjustable spring feature, to deliver its contents in from 4 to 7 days.

These cups can be furnished with check valve fittings between the lubricant fill hole and the delivery channel to make it possible to fill them when located in remote positions. They are made of steel from bar stock and are given a heavy surface of cadmium plate to enable them to resist the action of weather, abrasives and acid

fumes. Cups of both types, which are manufactured by the Dot Lubrication Division, Carr Fastener Co., Cambridge, Mass., are supplied in capacities of 1 oz. and 2 oz. The cups are designed to be opened, cleaned and closed without changing the adjustment of the parts. The insertion of a common nail through the pinhole in the tell-tale holds all the parts together during this process.

Gates Rubber Co. Builds New Power Plant

On July 27, the Gates Rubber Co., Denver, Colo., broke ground for the construction of a half-million dollar power plant designed to furnish light, heat and power for its group of twenty-one factory buildings in Denver. The power plant building will be of structural steel, concrete and brick, three stories high. Boilers of 600-hp. capacity each operating at 400 lb. pressure will supply a group of 1500-kw. condensing steam turbines. These boilers will be equipped with superheaters, economizers and mechanical stokers.

At present the Gates Rubber Co. uses 6 per cent of the total power and light consumed in the entire city and county of Denver. By operating with high-pressure turbines, thus permitting the second and even third using of exhaust steam for process work, it is able to effect economy that will pay for this entire new power unit within approximately 6 yr. The new plant will have a capacity of approximately 350,000,000 lb. of steam a year. Of this 35 per cent will be used for generating power and light, and 65 per cent for process work.

The new plant is being constructed under the direct supervision of Carl Ahlquist, chief engineer of the company and will be ready for operation by February 1, 1928.

News Notes

The Oklahoma Natural Gas Corp. through R. C. Sharp, president and general manager, has announced plans for connecting Oklahoma City with the Texas Panhandle gas field by a gas pipe line. The 22-in. line will extend from the Texas Panhandle to the Norge compressor station of the company near Chickasha whence a 16-in. line will run to the South Canadian river near Oklahoma City. At this point two 12-in. lines will connect running into Oklahoma City. The line will tap the Phillips Petroleum Co. holdings.

The Gulf States Utilities Co., a subsidiary of Engineers Public Service Co., has authorized Stone & Webster, Inc. to design and construct an extension to the Neches Station at Beaumont, Tex. This extension will consist of a 40,000-hp. turbo-generator and two 1540-hp. boilers. The present boiler and turbine rooms will be extended about 84 ft. to provide space for the new equipment. Outdoor switching facilities will be increased.

The Philadelphia Electric Co., Philadelphia, Pa., has contracted with the Pennsylvania Railroad to furnish its power requirements for electric railway operation for 20 yr. covering all present demands in connection with the electrification of several of its divisions and future requirements as may develop during the period noted. Power will be furnished at 13,200 v., 25 cycles, single phase and will be generated by the company at 60 cycles and then converted. It is understood that the Conowingo hydroelectric plant will be utilized for a considerable portion of this new service as soon as this station is ready for operation.

The Municipal Power Dept., Lansing, Mich., has work under way on enlargement in its municipal power plant. This includes installation of a new 20,000-kw. turbo-generator, which will increase the total capacity of the plant to 45,000 kw.

The City Council, Eugene, Ore., is perfecting plans for a municipal hydroelectric plant on the McKenzie River, to supplement an existing power plant now found inadequate for the city's needs. The entire plant is designed to develop ultimately a total of 75,000 hp.

The Kansas Gas & Electric Co. is enlarging its Neosho River station, southeast of Parsons, Kansas. A new 25,000-kw. General Electric turbine is being installed and will be in operation about October 15. Excavation has been started for an addition to the boiler room and three 1200-hp. Stirling boilers will be in operation by January 1, 1928. In addition to this work, plans are under way for a 60,000-v. steel tower transmission line which will connect with the Riverside Station of the Empire District Electric Co. outside of Joplin, Mo.

Pillsbury Engineering Co., of Minneapolis, has designed and is now installing additions to the municipal light and power plant at Blair, Neb., consisting of one Murray water tube 250-hp. boiler equipped with Westinghouse stoker and Webster feed water control, and one 375-kv.a. Skinner Unaflow engine. This additional installation will bring the plant up to 550 kw. capacity. Its operation is under the direction of C. E. Krause, superintendent, and Chas. Mortensen, chief engineer.

The Virginia Electric & Power Co., Richmond, Va., has approved an expansion program for the last half of the present year involving about $6,000,000. This includes the completion of the new steam plant at Norfolk, Va., a new underground transmission line at Richmond, work on transmission lines in northeastern North Carolina and other transmission lines throughout the district. The company is under the management of Stone & Webster, Inc., Boston, Mass.

Kentucky Utilities Co., Louisville, Ky., as result of expansion of business in various territories it serves has prepared a new building and reconstruction program involving the expenditure of more than half a million dollars. Principal item on this program is the construction of a 66,000-v. double circuit transmission line from the Earlington power station to Morganfield. This new line will be an important link in connecting the transmission systems of the Central Illinois Public Service Co. and the Kentucky Co.

Another 33,000-v. single circuit line will be built from Bardstown to New Haven and will be energized with power from the Dix Dam. Other transmission lines and substations will be constructed.

A new dam will be built across the Powell River at Pocket, Va., to increase the water supply of Pocket.

ANNOUNCEMENT IS MADE that when the Eleventh Exposition of Chemical Industries opens at the Grand Central Palace from September 26th to October 1, 1927, there will be from 350 to 400 exhibits, many of which will be shown for the first time. Various chemical societies which will meet in New York City during the exposition are co-operating closely with the management to insure its success. The fifth Chemical Industries Banquet will be held on September 28th at the Hotel Roosevelt under the auspices of the Salesmen's Association of the American Chemical Industry. On Wednesday, September 28th, a meeting of the Technical Association of the Pulp & Paper Industry is to be held at which an interesting program of papers dealing with that industry will be presented. Many new scientific and chemical instruments, together with new types of chemical apparatus of all kinds will be displayed. Complete details can be obtained from the Secretary, Exposition of Chemical Industries, Grand Central Palace, New York City.

THE INTERNATIONAL CONGRESS FOR TESTING MATERIALS to be held at Amsterdam, Holland, from September 12 to September 17, 1927, is considered to be the first manifestation after the war of international co-operation on the subject of testing materials. Among the papers to be read at the general meetings is one by T. D. Lynch of East Pittsburgh, Pa., on "Materials Testing as a Stimulus to Research." Other papers will be read by A. Mesnager, Paris, Prof. Korber, Dusseldorf, and Dr. Rosenhain of England. The subjects to be treated at the Congress are: A, metals; B, cement, concrete, stone and brick; C, miscellaneous (oils, rubber, wood, etc.). Meetings of the congress will be held at the University of Amsterdam.

ANDREWS-BRADSHAW CO., Pittsburgh, Pa., which has for some time owned a controlling interest in the Tracy Engineering Co., San Francisco, Calif., has recently acquired full ownership in the latter company's entire plant. Following this purchase the factory of the Tracy Engineering Co. has been moved to Pittsburgh. The latter company has been manufacturing the Tracyfier in its San Francisco plant, while the Andrews-Bradshaw Co. has been selling the equipment, both companies collaborating in research and development work on it.

BYLLESBY ENGINEERING & MANAGEMENT CORP., through H. W. Fuller, Vice-President, announces the appointment of H. W. Eales as head of the electrical engineering division of the engineering department, effective August 15. Mr. Eales comes to this position from St. Louis, where he was chief electrical engineer of the Union Electric Light & Power Co.

THE EDWARD VALVE & MFG. CO., E. Chicago, Ind., announces that its Cleveland representative has reincorporated under the name Tomlinson-MacLachlan, Inc., with new quarters at 1601 St. Clair Ave., Cleveland, Ohio.

STONE & WEBSTER, INC., has been authorized by the Carbide & Carbon Chemicals Corp. to proceed with the design and construction of an extension to its plant at South Charleston, W. Va. This will include a boiler house containing two 950-hp. boilers with stokers, a turbine room extension for one 1000-kw. turbo-generator to supply steam and power to the manufacturing plant, a 400-ft. highway bridge, an intake structure and three 10,000-g.p.m. centrifugal pumps to supply water to the plant.

MARION MACHINE FOUNDRY & SUPPLY CO., Marion, Ind., announces that September 10th is the 25th anniversary of the founding of the company.

YARNALL-WARING CO., Chestnut Hill, Philadelphia, Pa., has established an office at 314 Wright Bldg., Tulsa, Okla., in charge of Caleb L. Horne, district manager, formerly with the Texas Co.

ROBBINS & ROBBINS, 801 Tchoupitoulas St., New Orleans, La., have been appointed sales representatives in Louisiana and Mississippi for Graver Corp., East Chicago, Ind.

WM. B. SCAIFE & SONS CO., Oakmont, Pa., announces that J. R. Sproat has recently been appointed superintendent of its factory, succeeding G. A. Meckel, whose death occurred several months ago.

L. J. WING MFG. CO., New York, has recently appointed A. D. Foster, Mo. National Bank Bldg., St. Louis, to handle its line of equipment in the St. Louis territory.

THE EARLE GEAR & MACHINE CO., 4707 Stenton Ave., Philadelphia, Pa., announces the opening of a New York district office at 95 Liberty St., New York City, in charge of C. N. Walsh and George E. Barrett. The company also maintains a district office in charge of Wm. H. Allen at 110 State St., Boston, Mass.

ORDERS RECEIVED by the General Electric Co. for the three months ending June 30 amounted to $78,105,247 compared with $78,972,062 for the second quarter of 1926, a decrease of one per cent, President Gerard Swope has announced. For the six months ending June 30, orders totalled $165,655,828, representing a decrease of six per cent compared with $165,405,720 in the corresponding six months of 1926.

THE UNION GAS & ELECTRIC CO., Cincinnati, Ohio, has concluded an agreement with the Cincinnati Street Railway Co. to furnish its power requirements for electric car service, to become effective at an early date. It is understood that the street railway will abandon its power plant while the Union Gas & Electric Co. will arrange for increased facilities to carry the new load.

THE BUREAU OF YARDS & DOCKS, Navy Dept., Washington, D. C. is asking bids, no closing date announced, for complete power equipment for the heating plant of the Naval Training Station Hospital, Great Lakes, Ill. This is to include four 300-hp. water tube boilers, engine-driven chain-grate stokers and all necessary auxiliaries and accessories as per Specification 5405.

ANNOUNCEMENT IS MADE by the American Society of Mechanical Engineers that W. F. Joachim, Mechanical Engineer, Langley Memorial Aeronautical Laboratory, has been selected to receive the Rudolph Diesel award for 1927, consisting of a suitable certificate and a cash prize of $100.00 for his paper entitled "Oil Spray Investigations of the National Advisory Committee for Aeronautics." This paper was presented at the Oil Power Week meeting, April 21 to 23, 1927 at Pennsylvania State College, State College, Pa. The Rudolph

Diesel Award is given annually in connection with the activities of Oil Power Week for the best written contribution towards the advancement of oil engines delivered at any of the meetings held throughout the country.

NEW YORK EDISON CO. in its generating station at 14th Street and East River, is planning to install an electric generator rated at 160,000 kw. This will be driven by a tandem-compound steam turbine. Generator will be rated at 160,000 kw. at 1.0 power factor, 1500 r.p.m., 3 phase, 25 cycle and 11,400 v. Turbine will take steam at 400 lb. and a temperature of 700 deg. F. and will exhaust at one inch absolute pressure. The entire unit will be 82 ft. 7 in. long and will weigh over 1000 t. It is to be manufactured in Schenectady plant of the General Electric Co. and will be completed by October 1, 1928. General Electric Co. will also supply necessary transformers and two 40,000-kw. frequency changer sets for this plant.

COLONEL HUGH L. COOPER is chief consulting engineer on the hydro-electric project now building on the Dnieper River, with a staff of five American engineers. A 6000-hp. temporary power house has been erected to furnish power for the construction work, which is started on the dam. Seven 50,000 hp. units will be installed, the work to be completed in 5 yr. at estimated cost of $70,000,000. Professor I. G. Alexander, originator of the project, is in this country and will remain for three months to study large hydro-electric and equipment manufacturing plants. His address will be 165 Broadway, N. Y., care Amtorg Trading Corp.

THE UNITED ELECTRIC LIGHT CO., Springfield, Mass., has awarded contract to Stone & Webster, Inc., of Boston, Mass., contract for the construction of the new 110,000-v. switching equipment and buildings on the recently purchased 50-acre tract in West Springfield, Mass. The work will cost approximately $650,000. The work is to be completed so that the new equipment is ready for use by early winter.

APPOINTMENT OF GEORGE ST. J. PERROTT of North Dakota as superintendent of the Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce was recently announced. Mr. Perrott succeeds Arno C. Fieldner, recently promoted to the post of Chief Engineer, Division of Experiment Stations. As superintendent of the Pittsburgh Station, which is the largest of the eleven experiment stations of the Bureau of Mines, Mr. Perrott will direct the activities of approximately 200 scientific, technical and other employes. These employes are conducting various investigations dealing with safety in mining, elimination of waste in mining and metallurgical industry and technology of fuels, gases and explosives. Mr. Perrott is a graduate of the University of North Dakota; during the world war he conducted important research work in the Chemical Warfare Service in charge of a unit in the Gas Mask Research Section. He afterwards investigated many problems in the technology of coke and of various types of explosives.

WHEN THE THREE DAMS of the Texas Power Corp. on the Guadalupe River in Texas are completed this summer, the first large important contribution to hydro-electric development in Texas will have been made. At each of these dams, power plants will be installed, their total capacity being approximately 11,000 kw. Two of the plants will operate as automatic, remote-controlled plants, while the third will be the control plant of the system and will be manually operated. All of the electrical equipment will be supplied by the General Electric Co. and the engineering of the project is being done by the Fargo Engineering Co.

THE CITY OF CHANUTE, KANSAS is installing a new 530-hp. Heine boiler which will be fired by gas. The city will also install a 1500 or 2000-kw. turbine in the near future and will double the size of its spray pond. E. A. Pearce is superintendent of the city light plant.

AMONG FUELS available for steam generation in Southeastern Kansas is gas taken largely from the Oklahoma and Texas Panhandle districts. Much of this territory is served by the Empire Companies, Natural Gas Division and affiliated companies. At the present time these interests are engaged in main line extension and the connection of production areas in Oklahoma and Texas Panhandle with Kansas, Missouri and Oklahoma markets involving an expenditure of $20,000,000 during the present year. This capital will be spent on the enlargement of pipe lines and compression facilities throughout the system. These improvements will practically double the carrying capacity of the Empire Companies' main lines which now deliver more than 100,000,000 cu. ft. of gas daily throughout the year. Contract for gas compressor equipment was let to C. & G. Cooper Co., Mt. Vernon, Ohio, and covers eleven 1000-hp. and four 500-hp. gas engine driven compressors and six 190-hp. auxiliary electric attachments. There are at present 13 compressor stations in operation on the Empire Natural Gas system. These, together with five stations contemplated, will give a total capacity of over 50,000 hp.

Books and Catalogs

MECHANICAL APPLIANCES, Mechanical Movements and Novelties of Construction, by Gardner D. Hiscox. Sixth edition, 6 by 9 in., cloth, 412 pages, illustrated; New York, N. Y.; $4.00.

This is a collection of 1890 engravings of different mechanical motions and appliances, accompanied by appropriate text. It is divided into eighteen sections or chapters in which the subject matter is classified under the following heads: Mechanical power; transmission of power; measurement of power; steam power; air power appliances; electric power and construction; navigation and roads; gearing; motion and devices; controlling motion; horological; mining; mill and factory appliances; construction and devices; drafting devices; miscellaneous devices; radio telephony and telegraphy, etc. The book should be of interest to inventors and all readers with mechanical tastes.

SAMPLING AND ANALYSIS OF GASES, 187 + XIV pages, 25 illustrations, 6 by 9 inches, paper. Published and sold by Carnegie Steel Co., Bureau of Instruction, Pittsburgh, Pa. Third Edition, 1927, price $2.

This book is the result of more than 2 yr. work of a special committee composed of chief chemists of the subsidiary companies of the United States Steel Corp. The book is divided into four parts. The first, 44 p., is devoted to apparatus, reagents and absorbing solutions.

In it are found a brief discussion of the sources of error in gas analysis, a detailed description of the construction, operation and care of the new bubbling pipette type apparatus and a section on the preparation and properties of reagents and solutions used in gas analysis.

Part II, covering 60 pages, deals with the sampling and the analysis of industrial gases with the apparatus described in Part I. Detailed directions are given for the sampling and analysis of flue and chimney gases, blast furnace gas, producer gas, by-product coke-oven gas, coal gas, blue gas, carbureted water gas, natural gas, mixtures of natural and coke-oven gas, mine air, and compressed, or cylinder, gases, using a special portable apparatus for the analysis of flue and chimney gases.

Part III includes 33 pages and deals with miscellaneous determinations that cannot be made with the regular Orsat gas analysis apparatus, such as hydrogen sulphide, organic sulphur, total sulphur, acetylene, hydrocyanic acid and cyanogen, light oil or benzene, tar and mineral solids, naphthalene, moisture, and dust in gases, with examples to serve as a further guide to the analyst.

Part IV, comprising the last 47 pages, deals with the measurement of gases, the calculation of gas volumes under different conditions, and a number of problems presented by the combustion of gases. An appendix, composed of twelve tables, gives the specific gravity, the weight per liter and per cubic foot, the B.t.u. values and the specific heats of gases under the standard conditions selected, the properties of water vapor, factors for the correction of observed calerimeter readings, and a long list of conversion factors.

The book, which stresses the importance of accuracy and recognizes the fact that it is not to be obtained in every case by a blind following of directions, contains a great deal of information on the sampling, analysis, measurement and combustion of gases, which makes it a work of interest not only to chemists, but also to combustion and efficiency engineers, students, and, in fact, any one interested in the combustion and handling of fuels.

GRAPHIC THERMODYNAMICS. By W. S. Huntington. D. C. Heath & Co., New York, 200 pp. $2.50.

PRESENTATION of a graphical method for the analysis of problems involving the heat equivalent of mechanical energy, particularly the varied problems relating to the compression and expansion of air, gases and vapors. As an introduction the first chapter covers briefly some of the elementary principles of thermodynamics essential to the study in hand.

INVENTIONS AND PATENTS. By Milton Wright. New York. 217 pages, $2.50.

When the man who conceives an invention has before him a vision of reward, it is easy to overlook the fact that much must be done before that vision becomes a reality. There are patent rights to be secured, pitfalls to be avoided, business opportunities to be sought and handled in certain ways. It is a long winding road that the inventor has to travel and this book tells in considerable detail the many things an inventor must consider.

The first chapter is in popular style telling of some of the huge fortunes that have been made from patents but the following chapters are more practical, covering in considerable detail all phases of domestic and foreign patents, trademarks and copyrights, with several chapters devoted to hints for financing, promoting and selling the patent after it is obtained. One chapter is headed, "Twenty Don'ts for Inventors," another, "The Questions Inventors Ask" and the last chapter is made up entirely of suggested legal forms. The pitfalls for new inventors, and court decisions of famous cases make interesting reading. The book is in effect a handbook of patents.

DEAN HILL PUMP CO., Anderson, Ind., in bulletin 1202, describes and illustrates Wait type steam turbines.

SWABY MANUFACTURING CO., 2010 Marshall Blvd., Chicago, Ill., in a two-page leaflet describes the Swaby automatic cellar drainer.

PRESSURE VESSELS, FIRED AND UNFIRED, are discussed in "Safe Practices Pamphlet No. 68" recently published by the National Safety Council, 108 E. Ohio St., Chicago.

S. F. BOWSER & CO., INC., Fort Wayne, Ind., has just issued a circular entitled "The World of Things that Bowser Does."

PENNSYLVANIA PUMP & COMPRESSOR CO., Easton, Pa., has just issued Bulletin No. 133 describing its Model 121 Pennsy-Portable Air Compressor.

CRANDALL PACKING CO., Palmyra, N. Y., in a new 108-page catalog No. 10 describes and illustrates a complete line of packing manufactured by this company.

SPARLING WATER METERS are described and illustrated in a sixteen-page booklet issued by R. W. Sparling, 945-951 North Main St., Los Angeles, Calif.

THE SWARTWOUT CO., Cleveland, Ohio, in bulletin S-20 describes fully the design and operation of "S-C" feed-water regulators and pressure differential valves. Many applications are given with details of the parts and tables of dimensions for use of designers.

LINK-BELT CO., 310 S. Michigan Ave., Chicago, Ill., has just issued data book 615, a 148-page illustrated book containing tables, formulas and complete data for the use of all those interested in belt conveyors. Various types of Link-Belt conveyors are described, with complete details of their parts, tables of dimensions and illustrations of their applications.

WESTINGHOUSE SPECIAL Publication 1780, recently issued, describes the new panel mounted supervisory control equipment, giving the outstanding installation features of this apparatus. This publication discusses synchronous visual type control, the audible-type control, the medium-frequency-type of control and the direct-wire type.

BUSCH-SULZER Marine Diesel engines, 6 cylinder of 3000 hp. as used in U. S. Shipping Board 9500-t. freighters and results of a block test are given in a brochure issued by Busch-Sulzer Bros. Diesel Engine Co., of St. Louis, Mo. Other types used for mercantile and submarine work are also shown.

THE BRISTOL CO., Waterbury, Conn., has just issued a new electrical catalog No. 1502 on recording ammeters. This describes and illustrates these instruments as made by Bristol Co. and a complete price list of ammeters and parts is included.

SMALL PUMPS in both centrifugal and reciprocating types for motor or belt drive are carried in stock by Goulds Pumps, Inc., of Seneca Falls, N. Y., which has just issued a circular describing the various styles and sizes.